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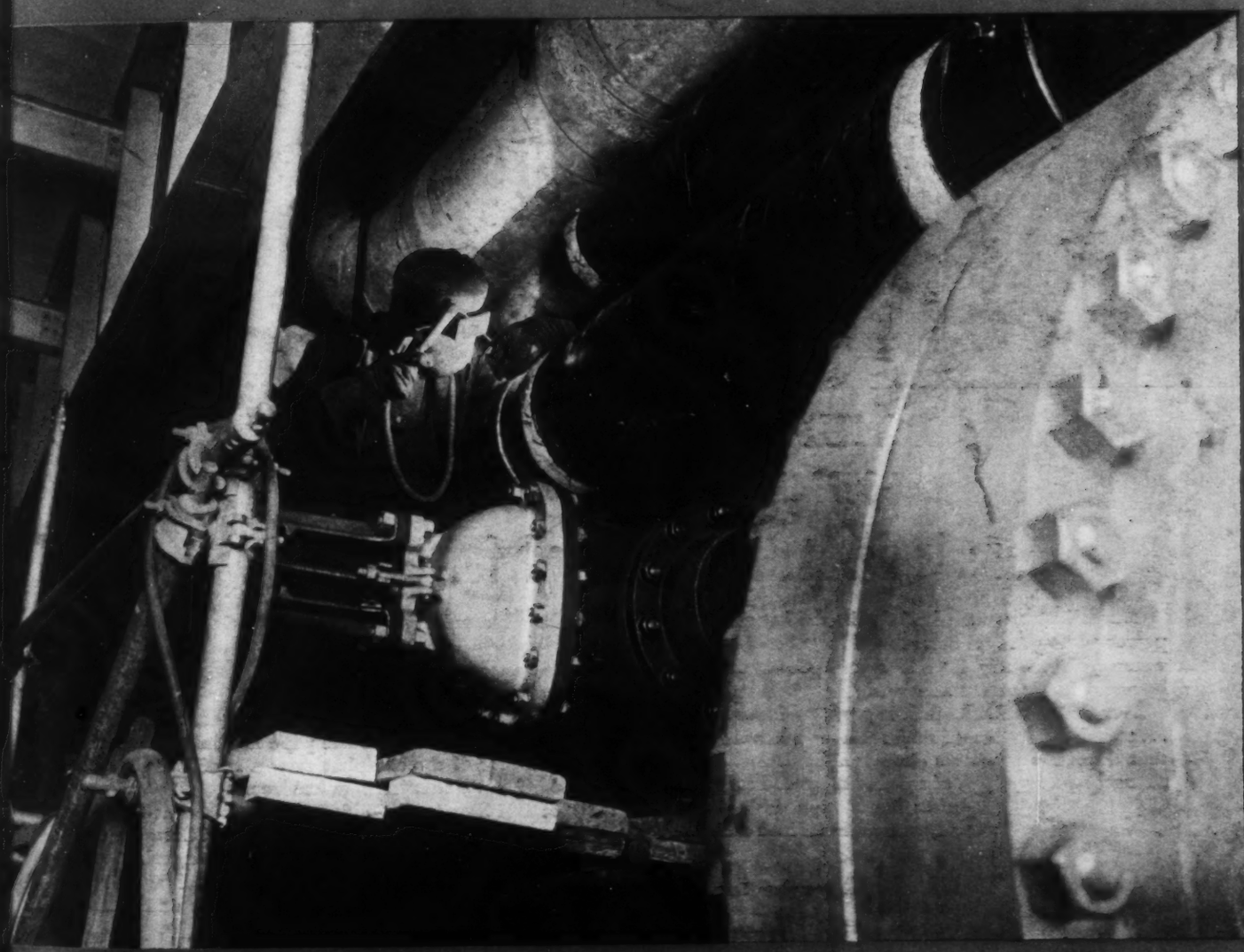

The section on fabrication details of the new code for pressure piping is described this month

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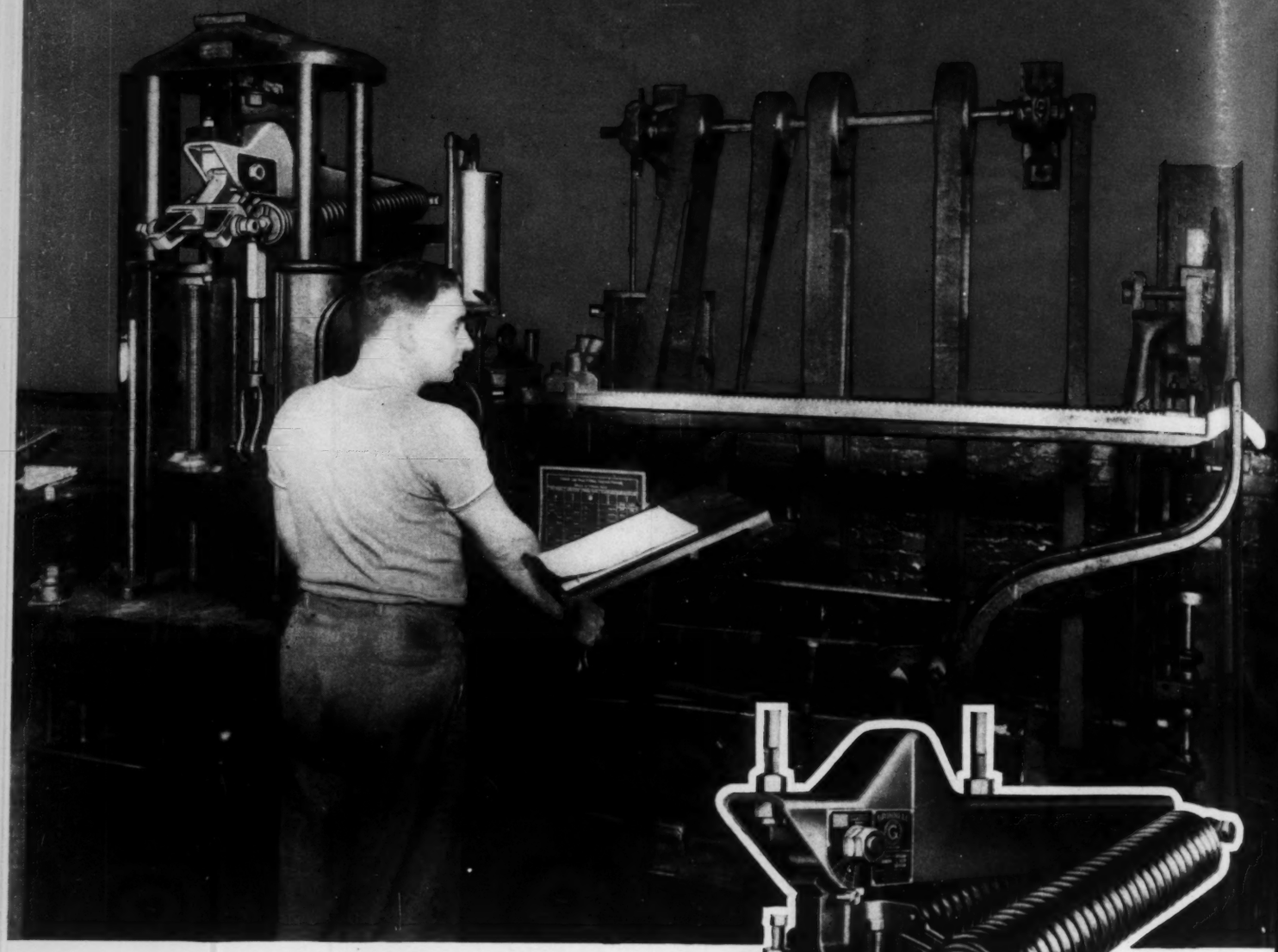

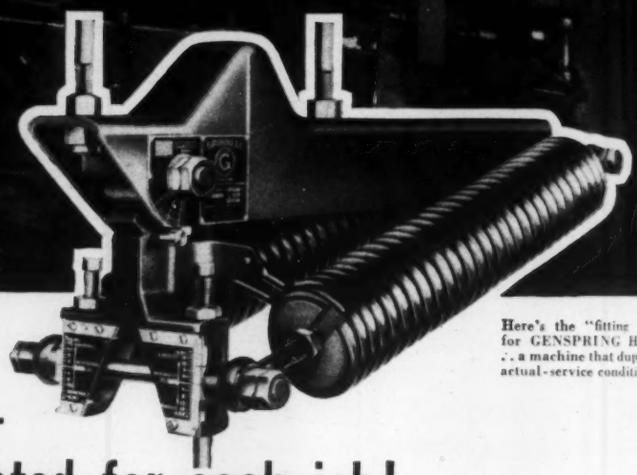

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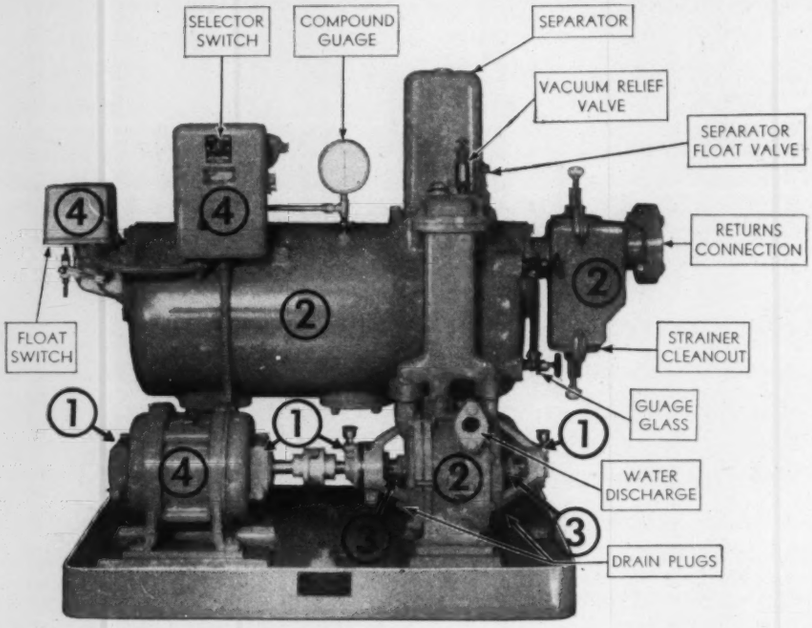
How to keep your Jennings Heating Pumps in First Class operating condition for Duration...



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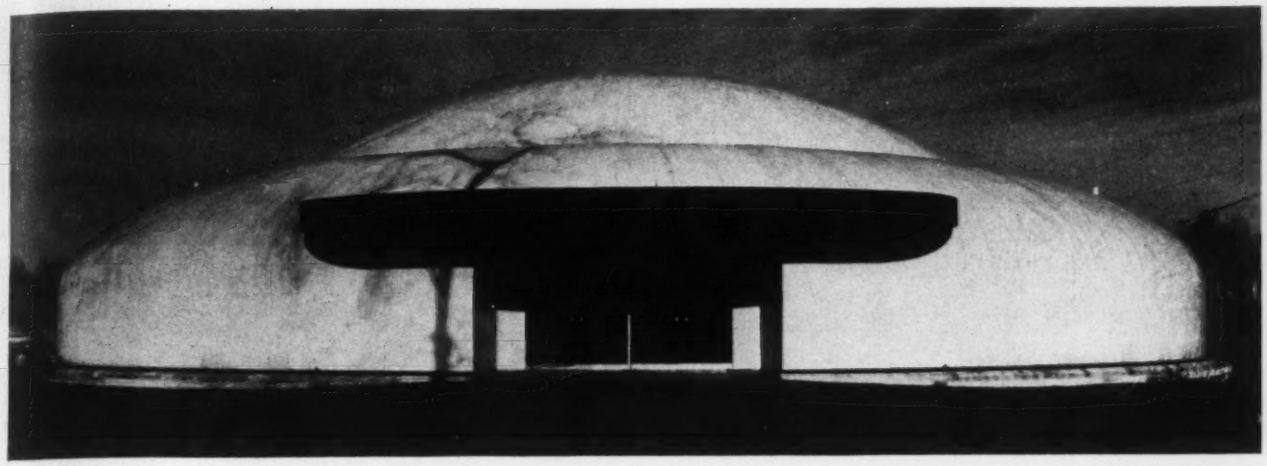


Air Conditioned Plant Restaurants Keep Busy War Workers Up to Par

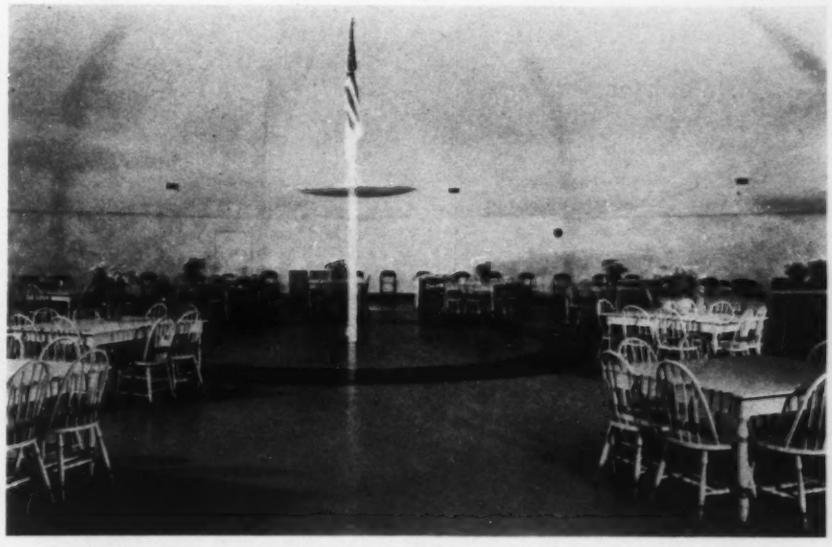
Tank Builder's Novel Building Looks Like Upside Down Teacup . . . . By Samuel R. Lewis

SUMMARY—Air conditioned plant restaurants and cafeterias are more or less standard equipment at factories working at high speed on production for victory, do much to keep busy office and plant employees up to par by providing attractive and comfortable surroundings during meal periods. Taking a leaf from its experience in building tanks for holding liquids and gases, Chicago Bridge completed last year an air conditioned, windowless plant restaurant of unusual design that looks like an inverted teacup. It is built of curved compression sheets, the steel plates being bumped into the desired shapes and welded into sections of considerable size in the shop. The sections were moved to the site by portable derrick and welded together. . . . Interior of the structure was insulated by spraying on an insulation. A 40 ton "Freon" refrigeration system provides cooling in summer. An oil burning boiler supplies hot water under forced circulation, for heating in winter. . . . The author, consulting mechanical engineer, is a member of HPAC's board of consulting & contributing editors

THE CHICAGO Bridge & Iron Co. has developed from a comparatively small steel bridge builder to a world-wide fabricator and erector of tanks for holding liquids and gases. The oil and gasoline tanks, many of unique and characteristic shapes, are made in three large plants.

Taking advantage of the economies suggested by Nature in the surface tension demonstrated by tear drops and the inherent strength of spheres, the elimination of flat, stayed surfaces has permitted this company to build very large pressure containers with a minimum of metal. Fusion welding by aid of the electric arc and the bumping of flat sheets into curved self-sustaining shapes have been developed into fine arts.

It was not a long or difficult step, therefore, from the conception of a concave structure surrounding a liquid to the picture of a convex structure supporting itself against wind and weather without any interior columns or beams. There was the fundamental reasoning that if tanks are highly economical in curved tension sheets, a building could be highly economical if built of curved compression sheets. The



owner wished to express this reasoning in practical form, largely as a matter of research.

The restaurant at one of the plants was outgrown and a new one was needed. In such a restaurant mechanical ventilation and refrigerated air supply for summer are highly desirable. There is no particular need for windows with their high maintenance and investment cost, need for continual washing, and necessity for shades and awnings.

The company retained Winston Elting, an architect not bound too tightly by convention, to develop the architectural design of the new restaurant. The detailed design of the steel and its fabrication was placed in charge of Clifford Orr, of Chicago Bridge, and the design of the mechanical equipment was made by Roy W. Shields and the staff of Samuel R. Lewis, consulting mechanical engineer.

Like Teacup

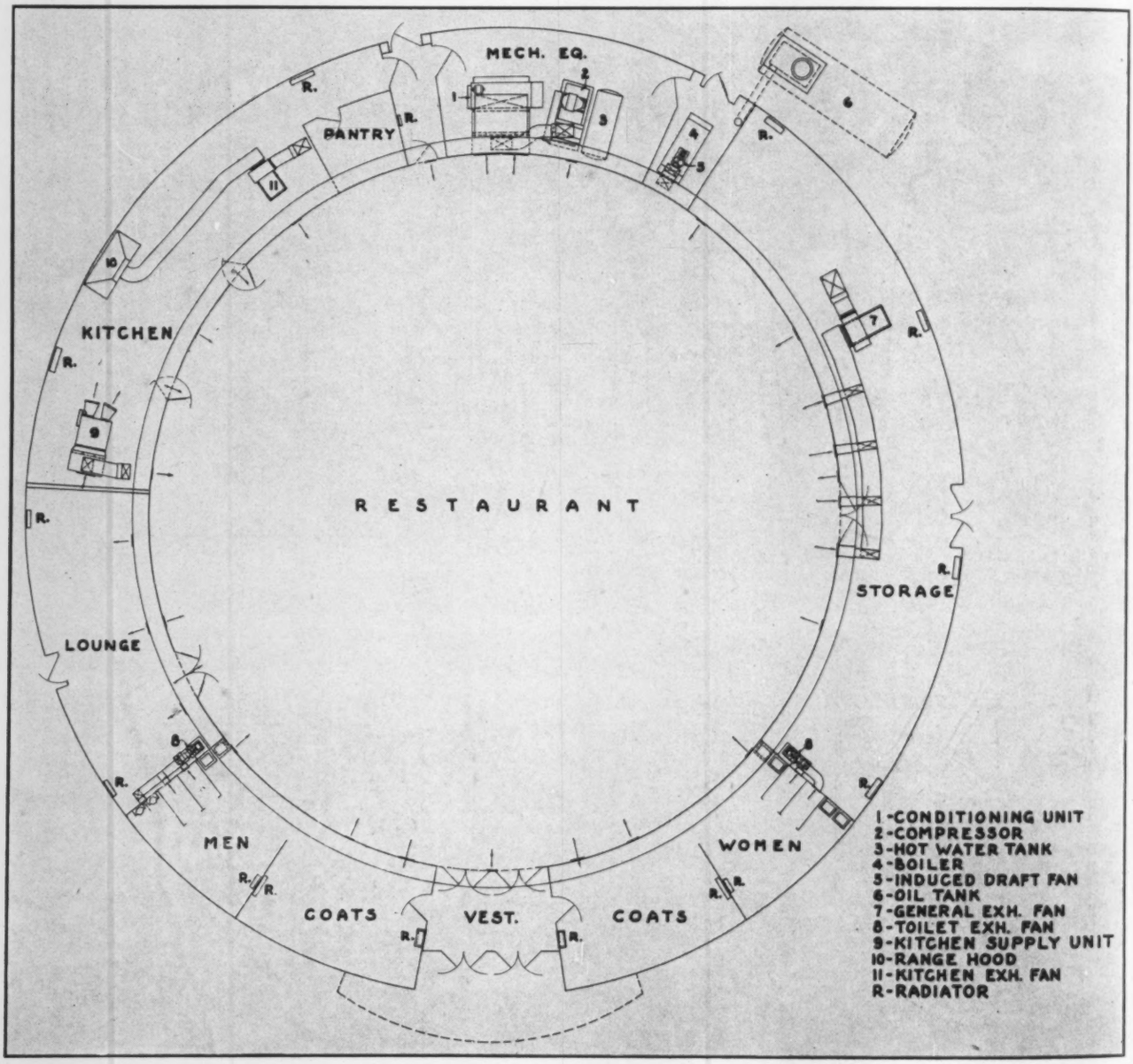
The restaurant proper is like an inverted teacup forming a dome 80 ft in diameter and 28½ ft high at the center, with a concentric bulge around its edges 14 ft wide. The space enclosed by the bulge is used for toilets, kitchen, storage and for the mechanical equipment.

The steel is $\frac{3}{16}$ in. in thickness, except for the main side wall under the dome, which is ¼ in., without a single post, beam, tie rod or strut. The originally flat steel plates were bumped or compressed into the desired shapes and were shop welded into sections of considerable size, many of which were identical, yet not too large to be handled by a portable derrick. These sections then were moved to the site and quickly were welded together by aid of several of the company's portable welding sets.

A remarkably small amount of scaffolding under the dome was needed. The investment cost of the essential building structure built in this manner by the company's experienced workmen probably was considerably less than that of its mechanical equipment.

Sprayed Insulation

The foundations comprise two concentric circles of concrete wall with a reinforced slab under the outer bulge, gaining a crawl space



for pipes and conduits. The floor under the dome rests on a compacted earth and sand fill.

The interior of the structure is insulated against heat transfer and noise by an insulation applied by a pneumatic gun, so that the basic heat transfer coefficient is in the order of 0.16 Btu per sq ft per hr per F difference in temperature indoors and outdoors. The insulation, which is a fibrous material projected simultaneously by the gun along with an adhesive, was installed in two separate layers so as to gain an especially smooth, light colored effect, which to the uninitiated looks like concrete. Illumination of the restaurant is entirely indirect from a pedestal under the center of the dome.

Air Conditioning and Heating

The air supply duct was welded into place as the sections were fabricated, fitting into the triangular shaped space where the bulge joins the dome. The air enters the restaurant through many horizontally discharging diffusing grilles directly from this duct, and is exhausted through the kitchen, the toilet rooms and other auxiliary rooms. Provision is made for partial air recirculation during occupancy, and for complete recirculation when heating or cooling the rooms prior to occupancy.

There are a few direct radiators, as in the entrance, toilet rooms, kitchen, etc., but the major heating and cooling is accomplished by indirect means. All of the air is filtered. Toilets and the kitchen have separate exhaust fans.

There is one steel boiler, burning heavy fuel oil, and hot water for winter heating is pumped directly through the boiler, gaining in this manner a highly efficient heat transfer. There are separate electric motor driven water circulating pumps, one for the kitchen radiators, one for the direct radiation in general, one for the indirect air heating convectors and a fourth for circulating the domestic hot water, which is warmed by transfer of heat from the main boiler.

Refrigeration in summer is by direct expansion evaporators and a 40 ton "Freon" system. There is automatic temperature control of all spaces the year around.

The mechanical equipment is generally conventional, except that since the dome and the bulge could not very well be marred by chimneys or ventilators, the function of these is accomplished by unobtrusive openings through the curved steel roof. The air supply intakes and the various exhaust outlets have watertight welded steel boxes below them, provided with drains, the air leaving or entering these boxes from their sides.

The boiler is provided with an electric induced draft fan which has an automatic time switch so that draft is in being before the oil burner cuts in and persists for a short time after the oil burner cuts out, so as to remove the gases from the heat transfer passages.

The exterior of the structure is painted directly on the steel, which fits so perfectly and is so smoothly welded at the joints that these practically are invisible.

At the opening luncheon, given by the company to the local chapter of the American Society of Civil Engineers, there were approximately 500 guests and the ability of the building to accommodate such a gathering while maintaining satisfactory comfort as to temperature, ventilation, illumination and acoustics, was well demonstrated.

The heating, ventilating and refrigeration was installed under contract by the Advance Heating and Air Conditioning Corp.

PROPER PIPING SYSTEM OPERATION VITAL TO EFFICIENT WAR PRODUCTION

DURING THE period of all-out production for war, involving the training of new personnel and a tendency toward a letdown of ordinary precautions due to the stress of overtime work, it is timely to give thought to the proper care, operation and maintenance of pipe lines, valves and fittings, which form the circulatory system for transporting the life blood of a manufacturing process to the points where it is needed, in the proper quantities and at the proper time. The production program is vitally dependent on the efficient performance of the piping system.

It goes without saying that in addition to providing adequate strength in the piping system, proper supports and provision for expansion and drainage should be provided when the piping system is installed and that the system should be maintained in perfect operating condition by suitable inspections at regular intervals. The proper procedure in the opening and closing of valves is also of vital importance in avoiding undue shocks caused by sudden changes in pressure and temperature.

In an article in the January, 1940, HPAC on standard bypasses for main control valves the necessity of the gradual opening and closing of main control valves was emphasized and it was pointed out that due to variations in service conditions two series of bypass sizes were necessary in order to provide the required control of the time element in the opening and closing of a valve under the various types of service occurring in practice.

The present vital need for maximum production makes this an opportune time to remind ourselves of the importance of maintaining proper control of flow in pipe lines, so as to protect these essential elements of the production machine from being subjected to unnecessary shocks and strains. The sudden release of pressure into an empty pipe line, by opening a closed valve too rapidly, may cause disastrous shocks and an accident involving the piping system in a manufacturing plant, even when it does not result in loss of life or damage to other equipment, is very likely to disrupt the production program of the plant.—JOHN J. HARMAN, general secretary, Manufacturers Standardization Society of the Valve and Fittings Industry. Member of HPAC's board of consulting and contributing editors.

Reinforced Concrete Pipe Used for Underfloor Air Ducts at New Plant

100,000 Cfm of Air Removes Heat Generated in Making Fluorescent Lamps for War Plants . . . . By S. M. Brown

ONE INNOVATION at the new fluorescent lamp plant of the Hygrade Sylvania Corp. is the use of reinforced concrete pipe, installed under the floor, for air ducts. Lamps made at this plant are being used in war production factories.

A large amount of heat is generated in the production of the lamp bulbs. Calculations showed that it would be necessary to introduce 100,000 cfm of air at 60 F to keep the plant at comfortable operating temperatures during the summer months. Using a maximum velocity of 2000 fpm, a main duct with an area of 50 sq ft would be required. Overhead ducts of this size were out of the question. Underfloor reinforced concrete tunnels were very costly, so the use of concrete pipe was conceived as a practical solution.

The largest size of pipe obtainable had an inside diameter of 82 in. so a dual service of one 82 in. pipe and a 54 in. pipe was laid out, extending from the air washing unit, situated outside the building, to a concrete chamber which is situated in the center of the building transversely, and at about the third point longitudinally. Long sweep elbows of galvanized iron with deflecting vanes were used in this pit to make the 90 deg bends from the service to the trunk lines, the 82 in. pipe being used to service approximately the front two-thirds of the building, and the 54 in. pipe the rear third.

Pipe sizes were stepped down to 42 in. at the extreme ends, always keeping the velocity at 2000 fpm or less. The tops of all concrete pipe were installed level at 16 in. below the finished ground floor, and bevelled fills of brick and mortar were used where the pipes changed size.

The branch lines were made of salt glazed vitrified tile, and taken off at a 45 degree angle, at the center of the pipe with the tile extending into the concrete pipe to act as a scoop. Single connections were made with 12 in. tile, and double ones with 18 in. tile. Where the 18 in. lines changed to 12 in. for the floor outlets, the 12 in. bell was inserted in the 18 in. and the joints filled with mortar. This permitted a considerable variation, so that with the use of 1/8 and 1/16 bends the outlets through the floor would hug the interior columns and not use up excessive floor space.

The greatest amount of heat is generated on the first floor, so two-thirds of the outlets were planned for this area and the other third were extended with sheet metal through the second floor. Sheet metal shoes were caulked in place where each tile outlet came through the concrete floor,

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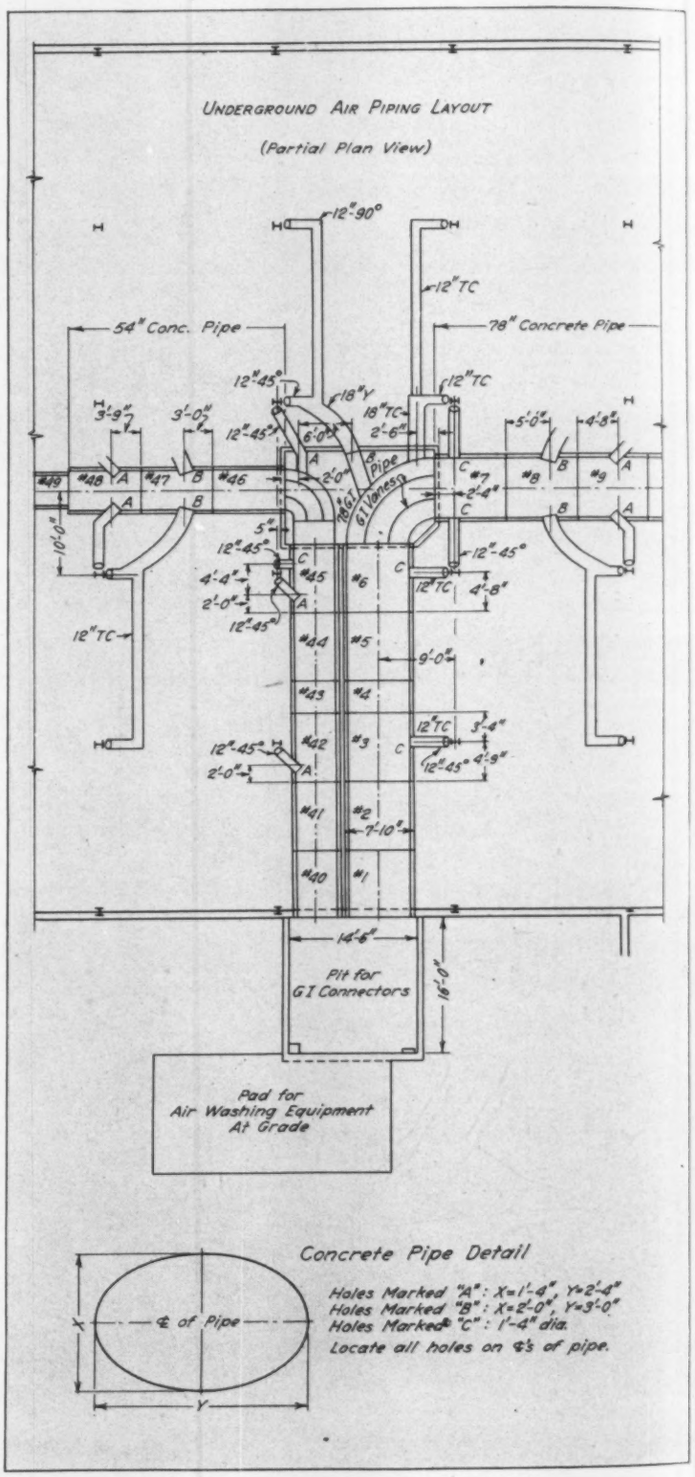


TVA's Watts Bar Steam Plant Augments Hydro Power for War Production

H. J. Petersen Explains Design and Installation of High Pressure Steam Piping

SUMMARY—During 1939 and 1940, with the load steadily increasing due to defense power requirements, it became more and more evident that the Tennessee Valley Authority's hydroelectric system should be augmented by additional steam generating capacity. The Watts Bar steam plant accordingly was authorized as an emergency national defense project, and is now generating power for war production. . . . Mr. Petersen, principal mechanical engineer, supervised the design of the piping and describes its features here, confining his remarks to the high pressure steam lines and the safety valve vent piping. The vent piping design, incidentally, was checked in accordance with the principles brought out in Max W. Benjamin's article published in the October, 1941, HPAC. . . . Mr. Petersen devotes particular attention to the field welding procedure, preheating and stress relieving

DURING 1939 AND 1940, with the load steadily increasing due to defense power requirements, it became more and more apparent that the Tennessee Valley Authority's hydroelectric system should be augmented by additional steam generating capacity, since this would provide a quicker source of added power than could be obtained in any other way. This was further emphasized by the need to increase firm power during periods of low river flow, and to provide capacity during flood periods when the hydro output would be reduced. Accordingly, Congress authorized the construction of the Watts Bar steam plant as an emergency national defense project. The steam plant is situated approximately 3600 ft downstream from the Watts Bar hydro plant.

The steam turbogenerators run at 1800 rpm. Each has a capacity of 60,000 kw at 0.9 power factor. They are designed for continuous output at unity power factor, or 66,700 kw under normal steam pressure and temperature conditions, and with steam taken at four extraction points for feedwater heating. The steam conditions at the throttle are 850 psi ga and 900 F, with 2 in. of mercury absolute back pressure at the condenser. Each turbine is connected to a pulverized coal fired boiler, with a rated capacity of 600,000 lb per hr of steam, with steam at the superheater outlet at 900 psi ga and 900 F.

The plant is designed to operate essentially on the unit system, but cross connections for emergency use are provided on the main steam and boilerfeed systems between the first and second units and between the third and fourth units. Inasmuch as this paper deals primarily with the high pressure piping, no detailed discussion of the units and their auxiliaries and the heat balance will be included.

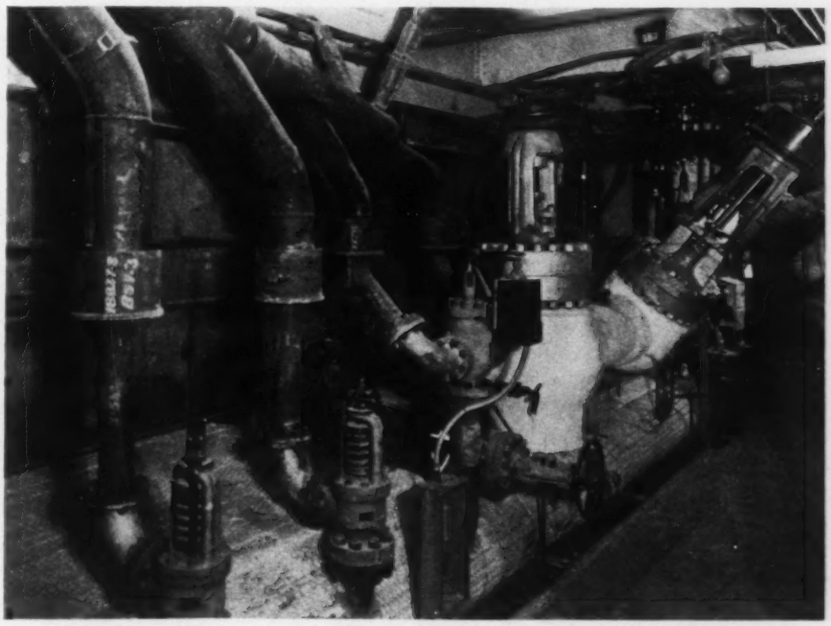
While the term "high pressure piping" is relative and could be applied to almost any system carrying steam at 300 psi and above, the application in this article has to do specifically with the main steam piping between the boilers and turbines, and the cross over connections between the boilers. The pipe for this system complied with ASTM specification A206-39T, schedule 100; this schedule covers service up to 900 psi and 900 F. Ferritic grain size of this carbon molybdenum pipe was specified to be within a range of No. 3 to No. 6.

All welded construction, conforming to the code for pressure piping, ASA B31-1, was specified for this pipe with field welds kept to a minimum. All welds were made up with backing rings. Backing rings were made from carbon molybdenum steel. A detailed discussion of welding is given later.

Main Steam Piping

The main steam piping was designed for maximum capacity and flexibility, consistent with the economics and other factors limiting

Superheater header, showing (left to right) two superheater safety valves, power control valve, angle non-return valve and motor operated boiler stop valve. Note the vent manifold from the safety valve exhausts; this vent piping was recalculated according to the principles given in Max W. Benjamin's article in the October, 1941, HPAC



such characteristics. Fourteen inch outside diameter pipe with a wall thickness of 0.937 in. (schedule 100) was found to give a low enough hoop stress and to be the proper size for the steam flow requirements. The problem then was to get the steam to the turbine stop valve with a minimum of pipe and bends, and still keep the metal stress below the code limit of 10,000 psi at the temperature of 900 F. A good many designs were made, some of which had certain advantages in lower pressure drop at the expense of flexibility, and vice versa.

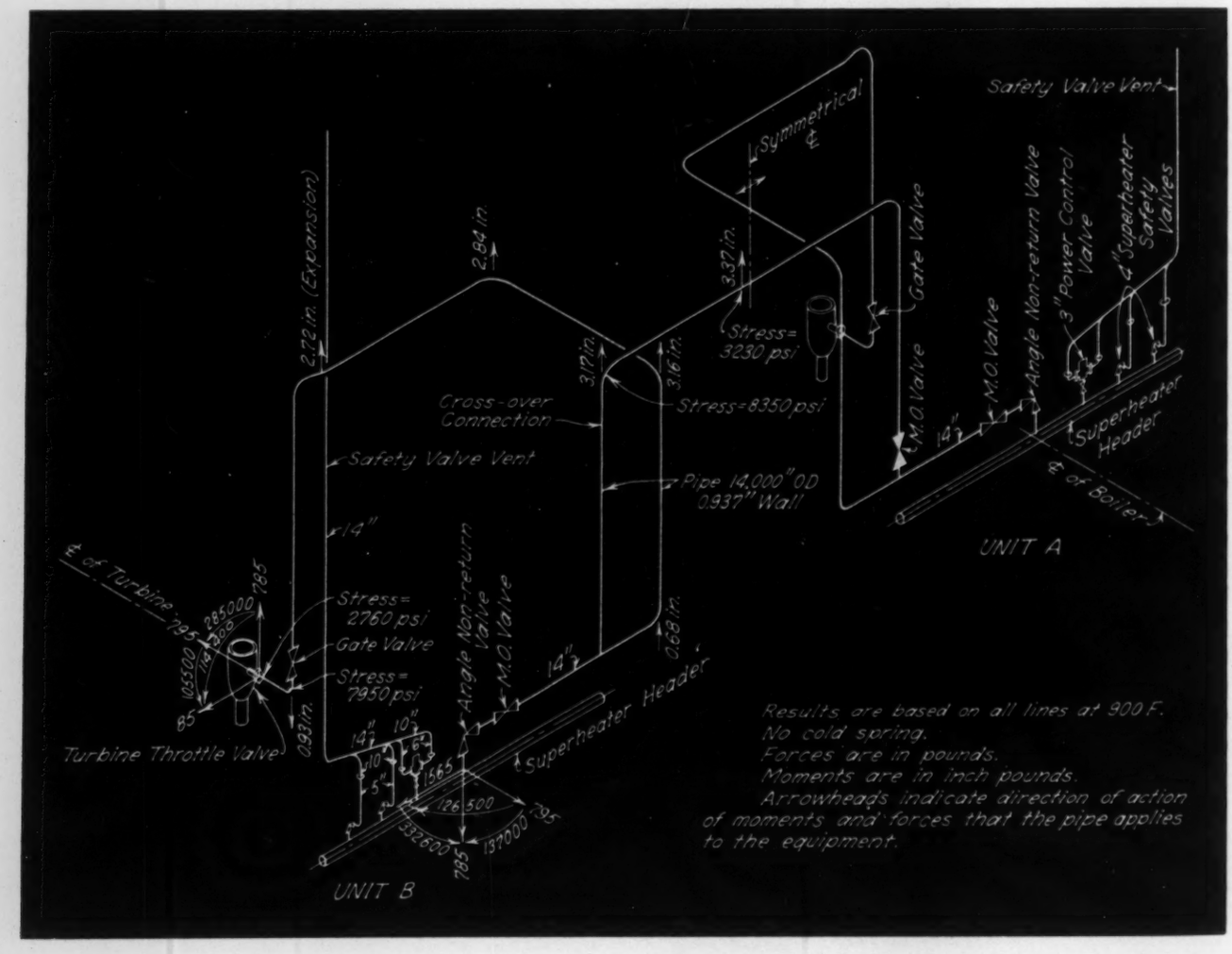
A contributing factor was the cross over connection between two units, which of course greatly added to the pressure drop when that cycle of operation was necessary. Each boiler and its auxiliaries has a maximum capacity of 700,000 lb per hr of steam with which to supply each of two turbines with 350,000 lb per hr through the cross over connection. In this way the total energy resulting from the steam from one boiler would be approximately 10,000 kw greater than when operating one turbine at its full load. This added factor was also taken into consideration in the pressure drop calculations. Since the operating pressure at the turbine throttle remains constant at 850 psi, any saving in pressure drop in the piping would be reflected in a lower drum pressure, with a consequent saving in fuel costs.

Stress in Bend at Throttle Valve

The final layout as ultimately designed and installed is shown in an isometric sketch. Moments, forces and stresses shown on this sketch are the result of calculations made from data obtained from an actual model test. A brief explanation of the stress determination in the bend adjacent to the turbine throttle valve shown in the sketch as having a calculated stress of 7950 psi follows:

Because the pipe is three dimensional and is restrained from rotation in any direction, three moments are present at that point. These are (1) a bending moment of 285,000 in.-lb in the plane of the bend, (2) a bending moment of 105,500 in.-lb perpendicular to the plane of the bend and (3) a twisting moment of 114,400 in.-lb. These moments were obtained from tests on the model, duplicating movement of the pipe as calculated from known expansion due to temperature increases. Combining the stresses obtained from these moments, the maximum stress at this point was found to be 7950 psi. The maximum stress at any point was found to be in the top bend of the cross over connection which was calculated to be 8350 psi, well within the allowable 10,000 psi. Stresses indicated make no allowance for cold springing of pipe.

Isometric sketch of main steam piping



Safety Valve Vent Piping

An interesting development occurred in the setting of the superheater safety valves shown in the isometric sketch. This was first attempted when the boiler was under pressure while it was being "boiled out," and the result was a considerable blow back of steam and water at the umbrella type fittings just above the safety valve. This caused some concern at first because the manifold type of construction used in combining the vents from the safety valves and the power control valve obviously entailed some assumptions in the design calculations. After the above blow back of steam, the vent piping was recalculated, using the method advocated by Max W. Benjamin in his article in the October, 1941, HPAC entitled Sizing Vent Piping for Safety Valves. This method applies the acoustic velocity principle, which is that the maximum velocity a fluid can attain in a conduit is equal to the velocity of sound in the fluid. Mr. Benjamin also states that the velocity pressure in the steam jet leaving the safety valves should be equal to or greater than the static pressure inside the vent pipe. The calculations indicated a sufficient margin in this respect.

Our conclusions were that the safety valves had been blown under abnormal conditions. While the unit was being boiled out only one burner was operating, and much of the steam from the drum condensed in the superheater (there being no output to the turbine). The saturated steam, condensate and moisture carryover from the drum was blown through the safety valves. The vent piping was uninsulated. The resultant mixture of water and steam in the vent piping increased the pressure drop through this line sufficiently to cause back pressure at the umbrella fittings.

Recently one unit has been in operation under normal pressure and temperature conditions with approximately 35,000 kw load on the generator, and the safety valves were blown by hand. The vent piping functioned satisfactorily, seeming to bear out the above conclusions. It may be that with automatic blowing of the safety valves as a result of a drop in load, or for any other reason, the manifold will cause some blow back of steam, even during conditions for which the system was designed. While this is not expected, it will be watched closely on the first unit, and the design of the vent piping changed if necessary.

Motor Operated Valves

All valves in the main steam line are 1500 lb series with stainless steel stems and stellited seats and discs. They are gate valves, outside screw and yoke pattern, with bonnets back seated to permit repacking under pressure. All valves, including the motor operated valves, have bypasses. However, motors for these latter valves are sized for operation under unbalanced line pressure.

Each boiler shutoff valve and the valve on the cross connection is motor operated, and each is controlled by a pushbutton at the valve and by a control switch on the boiler control board. Because the turbine throttle valve can be tripped from both the turbine control board and from the boiler control board, only a manually operated stop valve was installed in the turbine line ahead of the throttle valve. The function of this latter type valve is, of course, to take the throttle valve out of the line for any reason while its unit boiler is being used with the other turbine.

The insulation for the high pressure piping consists of 2 in. of high temperature insulation and a 2 in. thick layer of 85 per cent magnesia. This was covered with an asbestos cloth jacket sewed on with 16 ga copper wire.

Field Welding

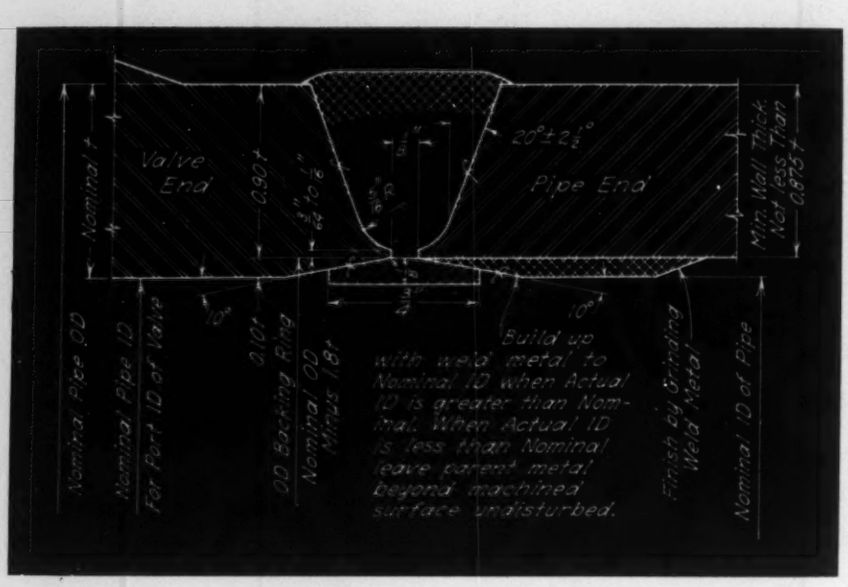
The piping contractor used essentially the following routine in the field welding of this pipe:

The pipe was aligned, fitted and held in place temporarily by four horseshoe shaped brackets which were tack welded across the joint, spaced at 90 deg intervals around the circumference of the pipe. These four brackets were removed after the first two beads had been run.

Preheating—All carbon molybdenum steel pipe was preheated to approximately 500 F before welding, and a uniform temperature between 400-600 F was maintained during the welding process. Both preheating and heat maintenance during welding was done by means of electric induction through the medium of an electric stress reliever. This machine operated on 220/440 volts at a frequency of 80 cycles.

The following procedure was used to prepare the pipe for preheating operations: Asbestos paper ⅛ in. thick was wrapped around the pipe on each side of the weld and wired in place. Two wraps were always used, which gave ¼ in. of insulation between the pipe and the copper conductor coils. The paper protected the weld from cold air currents, and also protected the asbestos insulation on the copper conductors from excessive heat reflected from the pipe itself. An asbestos insulated 500 MCM stranded copper conductor was then coiled around the pipe to within 2½ in. of the joint. This conductor was then passed about 18 in. above the weld and connected to a similar conductor which was coiled around the pipe on the opposite side of the weld. The same number of turns were used on each side of the weld and the conductor was wound in the same direction around the pipe on both sides of the weld. The number of turns was determined by the wall thickness of the pipe and the type material to be welded. An open space of about 5 in. was left at the weld. A thermocouple was welded to the pipe about 2½ in. from the joint and was covered by the conductors coiled around the pipe. This thermocouple enabled pipe temperature to be read directly in degrees Fahrenheit at the stress relieving machine.

Pipes were left wrapped as described after the welding operation had been completed, and no changes were made until just before the weld was to be stress relieved. Usually two welds were made simultaneously. To preheat for two welds the conductors described above were hooked in series. The stress relieving machine used was large enough to preheat two welds on all pipe not in excess of 8 in.


Valve End
Pipe End
20° ± 2½°
Nominal t
Min. Wall Thick. Not less Than
Nominal Pipe O.D.
Nominal Pipe I.D.
For Port I.D. of Valve
O.D. Backing Ring
Nominal O.D. Minus 1/8"
Build up with weld metal to Nominal I.D. when Actual I.D. is greater than Nominal. When Actual I.D. is less than Nominal leave parent metal beyond machined surface undisturbed.
Finish by Grinding Weld Metal
Nominal I.D. of Pipe

Typical detail of weld and backing ring

Welding operations were started after the pipe had been preheated to its required temperature. The welder ran one bead around the circumference of the pipe and then chipped all scale and flux from this bead, using a pneumatic chipping hammer. He cleaned the bead with a wire brush and was then ready to start running the second bead. This process was repeated until the complete weld was made. The welder signaled the stress reliever operator on completion of each band. This operator then started the machine and built up the temperature on the pipe while the welder was chipping and cleaning the weld. The stress reliever machine was not operated while the weld was being made, but was turned on during the intervals spent by the welder cleaning and chipping, as, due to magnetism, the machine could not be operated while a weld was being made. However, if the time required to run a bead was long enough for the pipe temperature to fall below 400 F, the machine was turned on and the welder stood by until the pipe had been reheated to its proper temperature.

On completion of the weld, it was wrapped tightly with a 2 in. strip of asbestos cloth, and the temperature was then raised to 600 F and the machine cut off. The asbestos wrapping insured gradual cooling. The welding rods used were ⅛ in. and $\frac{5}{32}$ in. in diameter; usually the first two beads were run with the ⅛ in. rod.

Stress Relieving — All carbon molybdenum steel pipe was stress relieved by the methods used for preheating. In stress relieving a temperature range of 1100-1250 F was maintained. The temperature was raised slowly and held at above range for a period proportional to the wall thickness on the following basis: One hour per inch of wall thickness, for carbon steel pipe. Two hours per inch of wall thickness for carbon molybdenum pipe.

In no case was the stress relieving less than ½ hr, and all pipe was allowed to cool uniformly in a still atmosphere. Stress relieving was accomplished by electric induction heating of a circumferential band twice the width of the weld and with the weld in the center of the heated band. While stress relieving, the conductor coils as described in connection with preheating were moved over the weld and a new thermocouple was placed on the weld. On carbon molybdenum pipe the complete cycle of preheating, welding and stress relieving was a continuous operation, with no interval from completion of weld until start of stress relieving.

This procedure resulted in excellent welds which were readily passed by the Hartford Steam Boiler Inspection and Insurance Co., who inspected all welding, both in the shop and in the field.

This power plant was designed and built by the Tennessee Valley Authority's own forces under the supervision of T. B. Parker, chief engineer. The design was in charge of George R. Rich, chief design engineer, assisted by Chas. T. Main, Inc., consulting engineers. The construction was under the supervision of A. L. Pauls, chief construction engineer, and F. C. Schlemmer, project manager. The design of the piping was under the supervision of the author, principal mechanical engineer. Grinnell Co., Inc., was the piping contractor.

[Concluded from p. 282]

and metal ducts with adjustable ventilators were connected to them.

Where practical, hoods with exhaust fans are used over the heat producing apparatus. A slight pressure caused by the introduction of the cooled washed air is taken advantage of, to force the remaining hot air out, through ventilating sections of the sash situated in the top rows of glass on the ground floor, and through power ventilators in the roof for the second floor.

The air washing and handling system was designed not only to cool the air for summer operation, but also to heat it for winter use. Ducts from both floors were connected to the intake end of the air washer to permit recirculation of air in the winter time. Water for cooling is obtained from an artesian well producing 400 gpm of 50-52 F water, adjacent to the air washer. Size of the pulley on the blower is changed to produce 70,000 cfm in winter.

The concrete pipe was furnished by a plant about seven miles away. There, undersize holes were cut in the pipe before shipment and trimmed to fit the branch lines on the job. The concrete pipe was scheduled for delivery, and unloaded and set in place direct from the trucks, showing additional economies.

This method of distributing air certainly worked out most economically, and the use of circular pipe definitely reduced friction losses. Being under the floor, no further insulation was necessary and the difference in temperature between the air leaving the washer and its delivery point can hardly be measured.

[For further information about this new plant, see pp. 162-163 of the March, 1942, HPAC.]

WAR PROBLEMS FORUM

ARMY DEVELOPS METHODS OF CONSERVING STRATEGIC RAW MATERIALS

ECONOMIES WHICH are also useful to civilian consumers are being developed for Army use and have resulted in reducing consumption of raw materials listed as strategic and critical, according to the War Department.

Each branch of the Army is contributing something to the study in conservation. The corps of engineers, for example, has substituted coated steel for brass on dozens of building items. The construction division of the corps of engineers has issued a circular letter on design embodying many of these changes. Following are some of the recommendations given in it for conservation of critical materials.

Prohibited Uses

Aluminum and Magnesium — No aluminum will be used except where there is an absolute military or safety necessity therefor. Lighting equipment of any kind, furniture, kitchen utensils or articles of regular supplies are not to contain aluminum or magnesium. Where no other substitutions are at all possible, low grade secondary aluminum will be substituted for primary aluminum if at all possible.

Asbestos (Amosite Fiber) — The use of 85 per cent magnesia pipe covering and block is prohibited in all insulation applications where the temperatures involved are below 250 F.

Copper — The use of copper or copper base alloy in various items and in all component parts thereof, is prohibited except to the extent that the use of any less scarce material is impractical, and in articles or parts thereof, which are being produced,

For use to comply with underwriters regulations, or safety regulations issued under governmental authority, provided the pertinent provisions of such regulations were, in either case, in effect both on October 1, 1941 and on the date of such use, and specifically and exclusively require the use of copper or copper base alloy to the extent employed, or

For use in chemical plants to the extent that corrosive action makes the use of any other material impractical, or

For use in laboratories and hospitals, where and to the extent that the physical and chemical properties make the use of any other material impractical, or

For use as part of the motive power or mechanical and electrical equipment of vessels other than pleasure craft, where corrosive action makes the use of any other material impractical, or,

For plating various items, provided that such plating is not primarily for decorative purposes; that the use of or normal wear on such items would make impractical any other form of coating; and that such item was formerly plated with copper or copper base alloy or, if such item was not formerly so plated, then provided that the total amount of copper or copper base alloy to be used in the plating of each such item is less than 5 per cent of the amount that was used in the manufacture of each such item immediately prior to November 1, 1941.

Items in which the use of copper or copper base alloy is prohibited, except as permitted above, include:

Air conditioning equipment (except small moving parts and bearings).

Grilles.

Heating and plumbing supplies—Bands on pipe covering. Convectors and local heaters. Hot water heaters, tanks and coils.

Pipe and fittings.

Ventilators and skylights.

Water containers for humidification.

Weatherstripping and insulation.

Valve handles.

Valves over 2 in. size (except seats, discs, stems and mountings).

The items in which the use of copper or copper base alloy is permitted, to the extent that the use of any less scarce material is impractical, include:

Condenser tubes, heat exchanger tubes (other than radiators which are used to control air temperature) and tube sheets in oil refining plants, in plants generating steam for public or industrial use and in plants generating electric power for public or industrial use, where and to the extent that corrosive action makes the use of any other material impractical.

Gas welding and cutting equipment, such as cylinder valves, pressure regulators, torches and tips.

Measuring, recording and control instruments, systems or equipment for use in industrial processes, such as pyrometers, thermometers, flow meters, pressure gages, gas analyzers and their associated control valves.

The working parts of pumps such as bearings, shaft, impellers, etc.

Bearings and bearing metal alloys.

Hot water pipe in permanent construction where the water is so active as to necessitate the use of copper or brass.

Tubing of ⅛ in. and ¼ in. for pneumatic controls, rate of rise sprinkler alarms and miscellaneous pilot controls.

Expansion joints — corrugated — in steam lines. (This type of joint is to be eliminated by basic design wherever feasible).

AIR CONDITIONED WAR

This is becoming an air conditioned war and in air conditioning the United States is as far ahead of the axis powers as it is in steel production, Dr. Willis H. Carrier, chairman of the Carrier Corp., said recently.

"In protecting powder and equipment, in speeding the production of thousands of articles of defense machinery back of the lines, and generally in helping men and machines to work better, air conditioning is month by month increasing its service to the all out defense of the nation," he said.

Copper tubing for refrigeration for sizes less than ½ in. diameter (only to the extent and until such time as ferrous tubing is commercially procurable).

Copper and brass tubing for transmission of meter impulses to recording instruments.

Brass trim in expansion joints, traps, controllers, gages, electric and pneumatic control apparatus, etc. where resistance to rust is necessary for proper functioning.

Cork — Cork and corkboard insulation is limited to use in the following types of refrigerating equipment and refrigerated spaces used to preserve food and medical supplies:

Cabinets and other small cold storage boxes, temperatures in which are to be maintained below 20 F; and

Cold storage rooms and "walk-in" boxes, temperatures in which are to be maintained below 40 F,

Except where permitted above, insulation materials other than cork will be used in structures of purely temporary character (five years), even though used for food preservation, except where insulation is definitely load bearing. In large permanent structures, cork insulation will not be used except in such parts where the temperature control is such as is covered above.

Substitutes

In order to assist in making substitutions for critical materials, the following list of substitutes has been prepared. [Only parts of complete list are given here—Ed.] These substitutes will be used where applicable. Where substitutes other than those listed are considered preferable, they may be used providing the same degree of conservation is effected.

Aluminum

Casing for unit coolers. Substitute steel, lacquered or enameled.

Unit heater coils. Substitute copper coils until steel coils are commercially available.

Asbestos

85 per cent magnesia pipe covering and block (containing amosite asbestos fiber) for temperatures under 250 F. Substitute cellular asbestos, glass fiber or rock wool.

Canvas

6 oz canvas pipe insulation cover. Substitute 3.8 oz cotton sheeting (Fed. Spec. HH-M-61).

Copper, Brass and Bronze

Bands on pipe covering. Substitute steel, lacquered.

Cases for pressure gages, brass. Substitute plastic, or enameled steel.

Float for sump pump switch. Substitute plastic float.

Union radiator valves, brass. Substitute cast iron body valve and right and left hand nipple.

Unit heater coils. Substitute steel coils when commercially available.

Ventilators. Substitute black iron or steel painted.

Water pan for humidification in theaters, copper. Substitute 16 ga painted steel.

Water pipe (inside buildings). Substitutes: *Permanent construction*—Cold water, galvanized wrought iron (Fed. Spec. WW-P-441a). Hot water; galvanized wrought iron (Fed Spec. WW-P-441a) unless water is so active as to make necessary the use of brass, Fed. Spec. WW-P-351. Grade A or copper tubing, Fed. Spec. WW-T-799, Type L. *Temporary construction*—Cold water, galvanized steel (Fed. Spec. WW-P-403a). Hot water, galvanized steel (Fed. Spec. WW-P-403a).

Water pipe (service). Substitutes: Cast iron (Fed. Spec. WW-P-421); galvanized steel (Fed. Spec. WW-P-403a); galvanized wrought iron (Fed. Spec. WW-P-441a); black wrought iron when experience has proved it satisfactory in the locality (Fed. Spec. WW-P-441a).

Cork

Vibration pads, cork. Substitute springs where feasible.

Nickel, Chromium, Chromium Nickel Steel Alloy, Copper Nickel Alloy

Floor and wall plates for piping (plated). Substitute steel painted.

Hot water storage tank. Substitute galvanized steel or vitreous porcelain enameled steel.

Monel pump shaft for forced hot water heating systems. Substitute naval brass or tobin brass.

Radiator valves, air valves and union elbows (plated). Omit plating.

Zinc (Protective Coating)

Air ducts, galvanized. Substitute black iron or steel sheets, asphaltum varnish, or iron hydroxide or oxide paint inside; lead and oil paint, or iron hydroxide or oxide paint outside.

Heating grilles, louvers and screens. Substitute painted steel.

The air conditioning & commercial refrigeration branch of the War Production Board has moved from 462 Indiana Ave. N. W. to the Penthouse of the Railroad Retirement Building, Washington, D. C. All mail should go to the new address.

Restrictions on the delivery of natural and mixed natural and manufactured gas to consumers, as provided in order L-31 issued February 16, 1942, have been extended to parts of six midwestern states. New areas brought under the restrictions are parts of Iowa, Kansas, Minnesota, Nebraska, Oklahoma and South Dakota.

All applications for priority assistance which do not specify a required delivery date will hereafter be returned to the applicant by the War Production Board, it has been announced.

Inventories of 19 kinds of supplies—including heating and plumbing, refrigeration, construction, builders, etc.—whether in the hands of wholesalers, distributors, jobbers, dealers, retailers or branch warehouses are strictly limited by order L-63, which superseded order M-67.

General limitation order L-100 of the WPB, issued April 17, requires that no persons shall place an order for a "critical compressor" unless expressly authorized by the director of industry operations of WPB on form PD-420. To secure such authorization, it is necessary to file form PD-415, in duplicate, with the WPB. "Critical compressor" means any crank and flywheel type horizontal reciprocating compressor or dry vacuum pump having a displacement of 50 cfm or more, or any other reciprocating compressor having a displacement of 300 cfm or more, and includes new, second hand and reconditioned equipment.

Certain types of pipe fittings required for shipbuilding have been exempted from the operation of schedule II to limitation order L-42, it was announced last month by the division of industry operations of WPB. An amendment to the schedule alters the definition of pipe fittings to exclude hydraulic or high pressure types; cast or forged steel fittings; and brazed or soldered brass or bronze fittings, whether screwed or flanged at any outlet. The amendment was prepared after conferences with the Navy Department and the Bureau of Standards.

The appointment of chiefs for two newly created sections of the WPB's plumbing and heating branch was announced April 22 by W. Walter Timmis, chief of the branch. They are John F. Steele, chief of the liquefied petroleum gas section, and David H. Butler, chief of the heating section.

P-126 GIVES HIGH PRIORITY RATINGS FOR AIR CONDITIONING REPAIRS

THE WAR Production Board has granted high preference ratings for deliveries of materials needed for repairs to air conditioning and refrigeration equipment.

The top rating—A-1-a—is available in the case of an actual breakdown of equipment used primarily to process, transport or store food and dairy products for the Army, Navy or Maritime Commission, or used in cold storage warehouses, meat packing houses under U. S. government inspection and blast furnace air conditioning. Other ratings, each in the A class, are provided to avert breakdowns of essential equipment and to maintain emergency repair service for existing equipment of all types, except domestic mechanical refrigerators.

The program is set forth in preference rating order P-126, and will be administered by WPB's air conditioning and commercial refrigeration branch. Ratings assigned under the terms of the order will be available only until June 30.

In addition to the A-1-a rating in the case of actual breakdowns of equipment deemed most essential for the country's health and safety, the order makes available the following ratings:

A-3 to avert an immediately threatened breakdown of any of the types of equipment listed above for which the A-1-a rating is available in case of actual breakdown.

A-3 in the case of actual breakdowns of equipment used generally to process, transport or store food and dairy products, including equipment in retail establishments where food is stored or served, and used in manufacturing plants actually engaged in filling defense orders as defined in priorities regulation No. 1.

A-8 to avert an immediately threatened breakdown of any of the types of equipment covered in the A-3 classification as listed in the preceding paragraph.

A-8 for emergency service to all other types of air conditioning and refrigerating equipment, except domestic mechanical refrigerators, and for deliveries of materials needed to maintain an emergency service inventory.

The ratings may be applied only by designated emergency service agencies and their suppliers. In order to obtain designation, an agency must be regularly authorized to represent a manufacturer, owner or lessee of air conditioning or refrigerating equipment, and must obtain a serial number from WPB after first making application on form PD-399.

J. M. Fernald, chief of the air conditioning and commercial refrigeration branch, said that manufacturers already have submitted the names of several thousand authorized service agencies throughout the country, and that the task of issuing serial numbers would be expedited.

"This is a case in which the manufacturers themselves will have a large share in the policing of this order," Mr. Fernald said. "We are relying a great deal upon their patriotism so that no one will receive a serial number who is not entitled to it. The industry has long awaited issuance of the order. If any abuses develop under it, it most certainly would be revoked."

In addition to the usual restrictions on use of the ratings to build up excessive inventories, the order lists several critical materials, such as copper, stainless steel and alloy steel, and a number of parts designed for installation in new equipment, for which the ratings cannot be used.

HEATING LIMITATION ORDERS COME THICK AND FAST

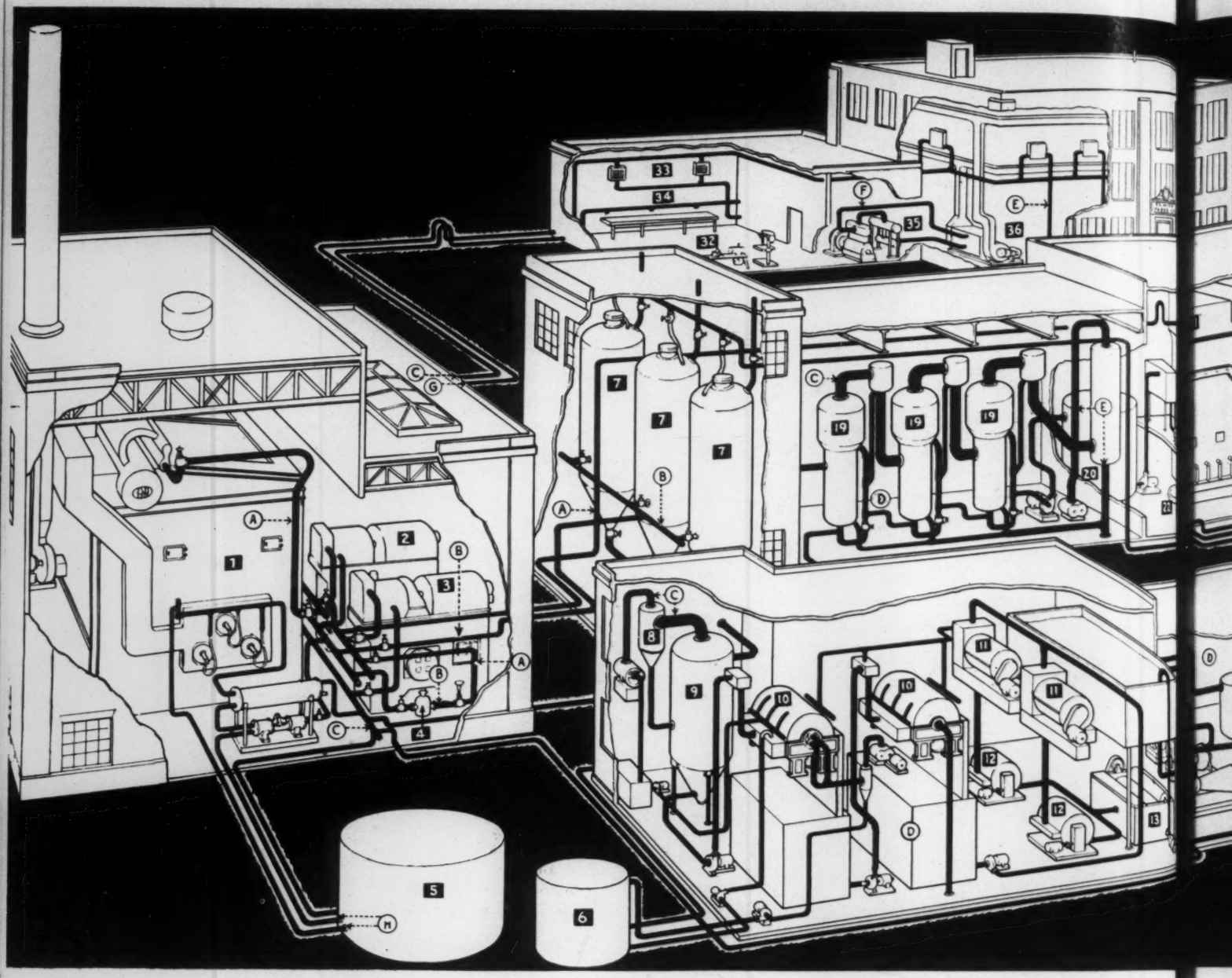
Limitation orders on heating equipment made the front pages of the newspapers throughout the country last month. Among them were No. L-79 freezing stocks of heating and plumbing equipment except where there is a preference rating of A-10 or better, in order to prevent dissipation of existing equipment for non-defense building, modernization or unnecessary replacements; the furnace order No. L-22, restricting the amount of iron and steel which may be used by furnace manufacturers, and issued because of the iron and steel shortage; and the orders ending oil burner and coal stoker production for residential use and limiting the production of commercial and industrial types to orders bearing an A-10 rating or better.

These orders, the order stopping non-defense construction, and the earlier limitation order on unit heaters, blast coils, unit ventilators, etc., while of course presenting numerous problems to those in the heating and air conditioning industry—including a great deal of paper work—in effect serve to "formalize" an already existing situation created by material shortages and priority regulations. They increase the priority ratings necessary to obtain heating and air conditioning equipment and are intended as additional assurance that such vitally important equipment will be used on the war production projects where it is most vitally needed.

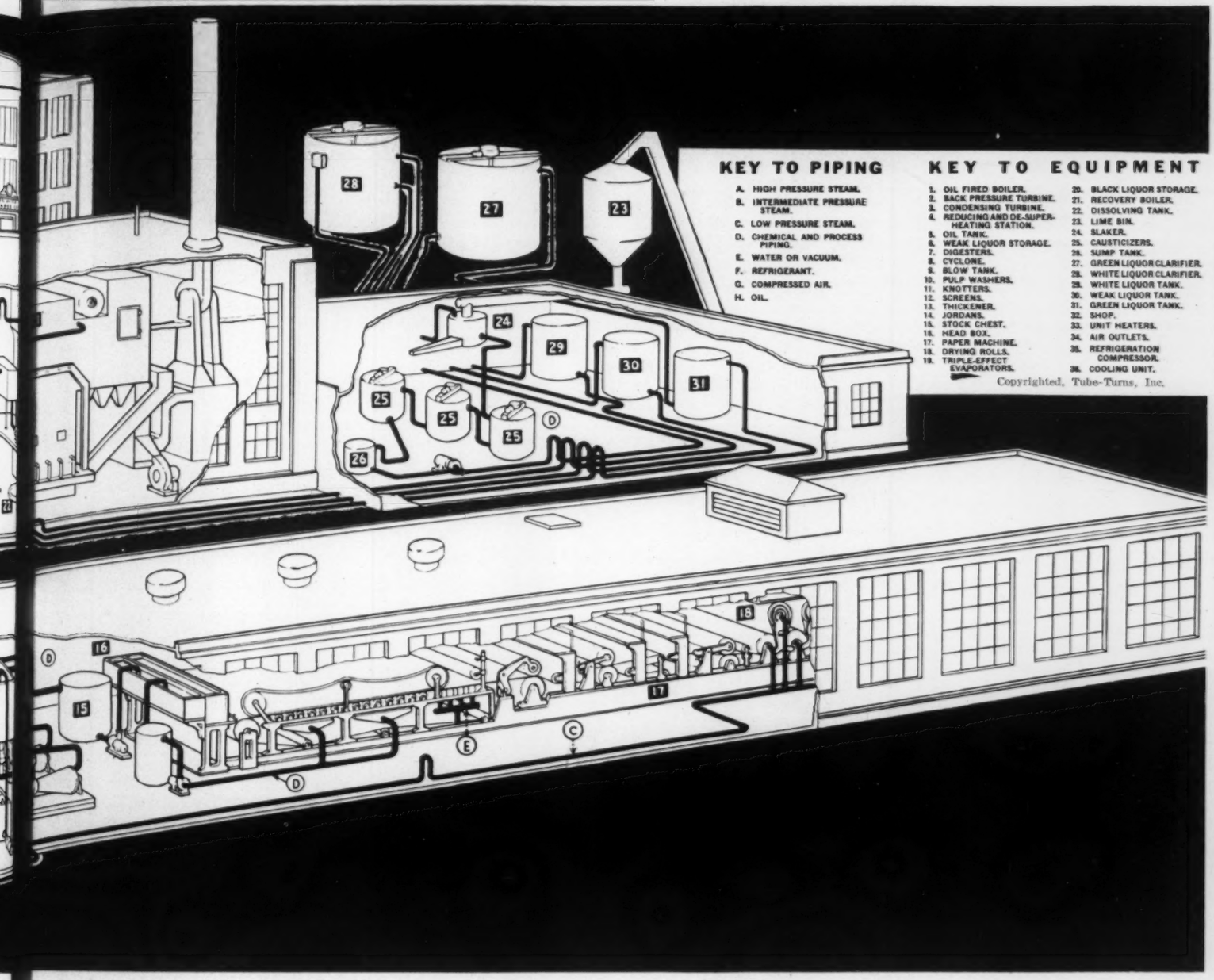
Conservation of critical materials in the manufacture or production of war materials is the high purpose of the War Production Board, says the Industrial Unit Heater Association in a special statement to HPAC. The WPB action of March 25, freezing all completed stocks of steam or hot water unit heaters, is a case in point. The advantages of unit heaters were the deciding factors in limiting their installation to certain end uses where the equipment would be of the greatest possible benefit to the war effort.

Although the freezing order on the face of it appears drastic, the actual effect has made very little change in the operation of the industry except insofar as certain procedures must be followed out to obtain release for shipment of unit heaters for the specified end uses, the association says.

As far back as August, 1941, the individual manufacturer began to set up his own limitations on the sale of unit heaters for certain essential uses. These limitations on use of necessity varied from one manufacturer to another. The freezing order therefore provides a uniform and legal method whereby unit heaters are confined to definite channels where the greatest need, in the opinion of the Army and Navy, exists.



PIPING --- INDUSTRY'S MOST IMPORTANT TRANSPORTATION SYSTEM ---- PLAYS VITAL ROLE IN ALL-OUT WAR EFFORT



THE PIPING systems in America's industrial plants—conveying everything "from soup to nuts"—represent the Nation's most important transportation system, consequently are performing an essential service in production for victory. The drawing above was prepared to visualize the many applications and kinds of piping services in a plant; a paper mill was selected as the example because its operations embody many different piping systems and because it includes the main types of lines common to general industrial plants as well as other piping found in the process industries. . . . The plant layout and piping have been simplified for clarity and ease of presentation, and the sizes of the lines have been somewhat exaggerated. All of the items of equipment, valves, traps, bypasses, controls, hangers and supports, and numerous other pieces of equipment which are essential to a piping system are of course not shown. (Original drawing furnished through the courtesy of Tube-Turns, Inc., Louisville, Kentucky.)

Viscosity Compensation for Oil Burners

Kalman Steiner Explains "Viscosity Compensation" and Gives Practical Suggestions for Layout of Installations

EACH BRANCH of engineering seems to accumulate a certain number of terms that must be designated later as misnomers. The expression *viscosity compensator* is one of these. It is probable that the name originated from a wish. Early in the days of oil burner designing, it was found that ordinary valves such as needle, globe and gate valves were not particularly well suited to regulate viscous flow. Clearly, viscosity had to be taken into consideration in attempting to regulate rate of fuel flow to the burner. Viscosity compensation therefore became a concept long before it became an actuality. Oil burner men wished they had a means of compensating for viscosity, and when something appeared on the horizon that seemed to offer *independence of viscosity*, it was erroneously called a viscosity compensator.

To the uninitiated, the term would imply a device that is in some way sensitive to the viscosity or change in viscosity of the liquid, and is in some way capable of responding to the stimulus of viscosity change, whereby it will so alter the flow conditions as to offset the effects of viscosity change. Actually, a viscosity compensator is unable to detect changes in viscosity, and of itself is unable to alter flow conditions should such a change occur. In fact, the viscosity compensator remains passive under viscosity changes—it does nothing at all, and it is to this fact that it owes its usefulness.

The full significance of the viscosity compensator is better appreciated from a brief review of the more common methods of metering flow, and an analysis of their faults. The needle valve was very widely used in early burner types. On the rather light fuel oils then in use this valve served its purpose satisfactorily, but as refining methods changed and fuel oils became more viscous and carried more sediment, the needle valve became subject to film formation across the rather narrow clearance between stem and seat, and

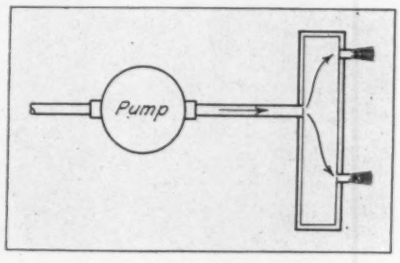


Fig. 1—Sketch illustrating principle of operation of a viscosity compensator

sediment was prone to deposit at this point of restriction. Even if neither film formation nor sediment deposit occur, the needle valve requires either that its setting or the setting of the pressure regulating valve be altered for each change in oil temperature or viscosity.

A refinement of the needle valve is the so-called metering valve, by which is meant a valve having an oil passageway cut into the stem itself, the aperture into the stem being formed as a sort of V notch having a rapidly converging angle. As the stem is moved up or down by turning of the valve handle, the exposed portion of the V changes rapidly. This makes the valve sensitive, and the shape of the orifice reduces the possibility of film formation or sediment deposit. But the amount of liquid passed through the orifice is a function of both pressure and viscosity, and since there is no way of varying the pressure automatically in accordance with viscosity changes, the flow varies with changes in fuel characteristics. The metering valve's chief usefulness is with manually controlled burners where the fuel temperature is held fairly constant, and with light oils.

Orifices have been used to some extent, but are subject to the same objection as the metering valve, plus the fact that an orifice is not readily adjustable in size, so that flow variation can be secured only by varying the pressure. This necessitates provision for changing the orifice plate whenever the desired change of flow rate lies above or below the working pressure range. For any given burner size a number of orifice plates having different sized orifices must be made available.

It might be mentioned in passing that the pressure regulating device, required as an essential part of the system with needle valve, metering valve or orifice, is itself a source of operating and maintenance problems. Apparently, therefore, in combination with any one of the three methods so far described, it cannot be said to add to the general degree of satisfaction obtained.

The viscosity compensator is no more able than the pressure regulator to detect change in viscosity, but the hydraulic conditions existing enable the viscosity compensator to be independent of viscosity. Searching for a more exact term, one might use the expression "viscosity dodger." Here we really have a contrivance so fashioned that viscosity changes have no effect upon the flow.

A rudimentary system that perhaps best illustrates the basic principles involved is shown in Fig. 1. A positive displacement pump is driven at constant speed and so maintains a constant flow of liquid. This liquid is discharged into a chamber which has two fixed outlets. Obviously, the combined streams issuing from the outlets must equal the pump discharge rate. Obviously, also, the rates of flow through the outlets bear the same ratio to each other as the outlet port areas. Finally, granted that the pump can maintain constant flow regardless of viscosity changes, and this is generally true within a very

SUMMARY—The expression "viscosity compensator" is a misnomer; a more exact term would be "viscosity dodger", for—in fact—the viscosity compensator remains passive under viscosity changes. It does nothing at all, and therein lies its usefulness. . . . Mr. Steiner explains the principle of the viscosity compensator, discussing its value and giving practical suggestions on its use and the layout of plants burning heavy fuel oil. . . . The author, mechanical engineer with the Chicago ordnance district, is a member of HPAC's board of consulting & contributing editors

wide range of viscosity, it follows that the ratio of division into two streams of flow is independent of viscosity. As a corollary, it can also be stated that the ratio of division is likewise independent of pressure and temperature.

To make a commercial device of such an arrangement, it is necessary to provide means for varying the port areas. It is then merely a question of adjusting the two areas until the desired rate of flow to the burner is secured. The second port of course becomes the return to storage, or to pump suction, as desired. In commercial applications, however, one other feature is essential. Since both ports are variable, a safeguard must be incorporated against both ports being completely closed, or against undue pressure rise occurring at any time. This safeguard is generally a spring loaded pressure relief.

Various forms of viscosity compensators have been evolved, all using the above principles. Some employ vertical motions to vary the port sizes, some utilize a rotary motion; in certain forms each port is independently variable while in others a single adjustment varies both. Again, the adjustment may be purely manual in one case and in another may be automatically variable to suit changing load demands.

A very simple form of viscosity compensator or flow regulator can be made up with two good metering valves and a pressure relief. For occasional application to unusual installations where burner equipment lacks this feature, dependable operation can be secured by such an arrangement.

An extension of the principle of orificing as found in a viscosity compensator is illustrated in Fig. 2. Here the division of the main stream into two smaller streams for feed and return is accomplished by causing the oil to pass through two valves having long tapering seats. The resistance through each valve may be varied, and for any given setting the ratio of the division is the ratio of the two resistances. Of course, the valve governing the return stream likewise governs the pressure under which the system works. A high pressure relief is also incorporated, giving direct bypass to the return line in the event undue pressure is built up. The pump of course discharges a constant stream into the central chamber, from whence the oil flows into the two valve chambers.

With any of the forms so far described, adjustment of the oil flow is manual; that is, the orifice or valve setting is made by hand. It is also necessary that there be some sort of automatic adjustment provided, so that the oil may be varied in synchronism with the air supply in accordance with load changes. In the form of viscosity compensator just described, a third valve is incorporated, acting as a bypass around the return adjustment. This third valve has a rotary port, and the stem is turned to vary the flow through it. A suitable linkage then connects the stem of this bypass valve to the mechanism that responds to load changes. As the bypass opens, the oil pressure of the system falls, thereby diminishing the flow to the burner. In the forms employing two orifices, the variable feature may be incorporated into the main ports if the valve utilizes a rotary motion, but if the main adjustment is in the form of a straight piston, then the auxiliary adjustment for variable fire must be a third port external to the compensator itself. In this latter case, a rotary valve similar to that just described as a bypass valve may be employed. In this case, however, instead of acting as a bypass around a main port the valve is placed in series with the feed port. As the load sensitive mechanism reduces the opening through this rotary port valve, it serves to reduce the flow through the feed port of the compensator, thereby shifting the ratio of division in the same manner that the main feed port would were it closed manually.

We have considered so far a single pump supplying fuel to a single burner. An extension of the principles so far discussed to the case of a single pump supplying two burners would call for either a single compensator from the feed port of which fuel would flow to the two burners in parallel, or a compensator on each burner with provision for both operating in synchronism so as to maintain the necessary orifice ratio. In general, attempts to set up a viscosity compensator arrangement for two or more burners fed from a single source will involve complicated piping schemes, and results will be dubious.

A much more satisfactory arrangement is to equip each burner with an individual pump, letting that burner operate with complete independence of the others by taking suction from a circulating stream of hot oil. Thus at any moment a particular burner may start automatically there is a source of hot oil available practically at its swivel connection, and its own pump and viscosity valve will constitute an independent system of flame regulation that cannot be affected by the firing rate of any other burner.

Fig. 3 gives a complete flow scheme for a plant having a multiplicity of burners using bunker C fuel oil. All essential equipment is in duplicate—storage tanks, circu-

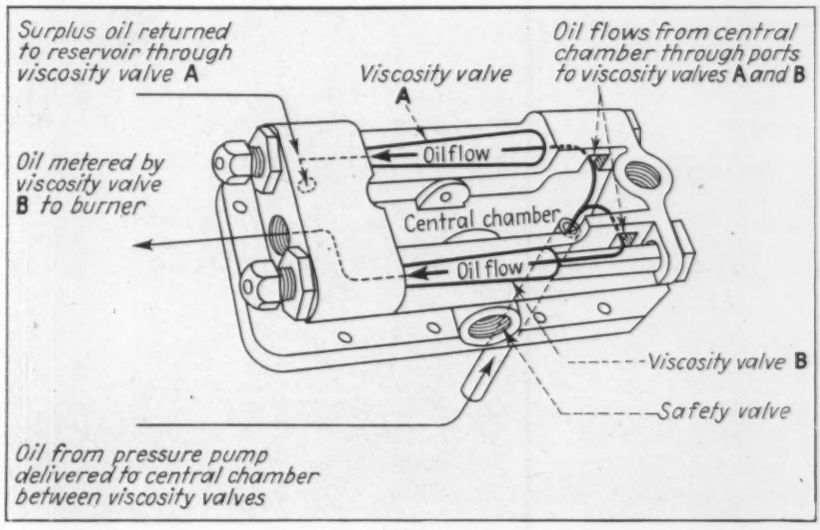

Surplus oil returned to reservoir through viscosity valve A
Viscosity valve A
Oil flows from central chamber through ports to viscosity valves A and B
Oil metered by viscosity valve B to burner
Oil flow
Central chamber
Oil flow
Viscosity valve B
Safety valve
Oil from pressure pump delivered to central chamber between viscosity valves

Fig. 2—Operation of this viscosity compensator is described in the text

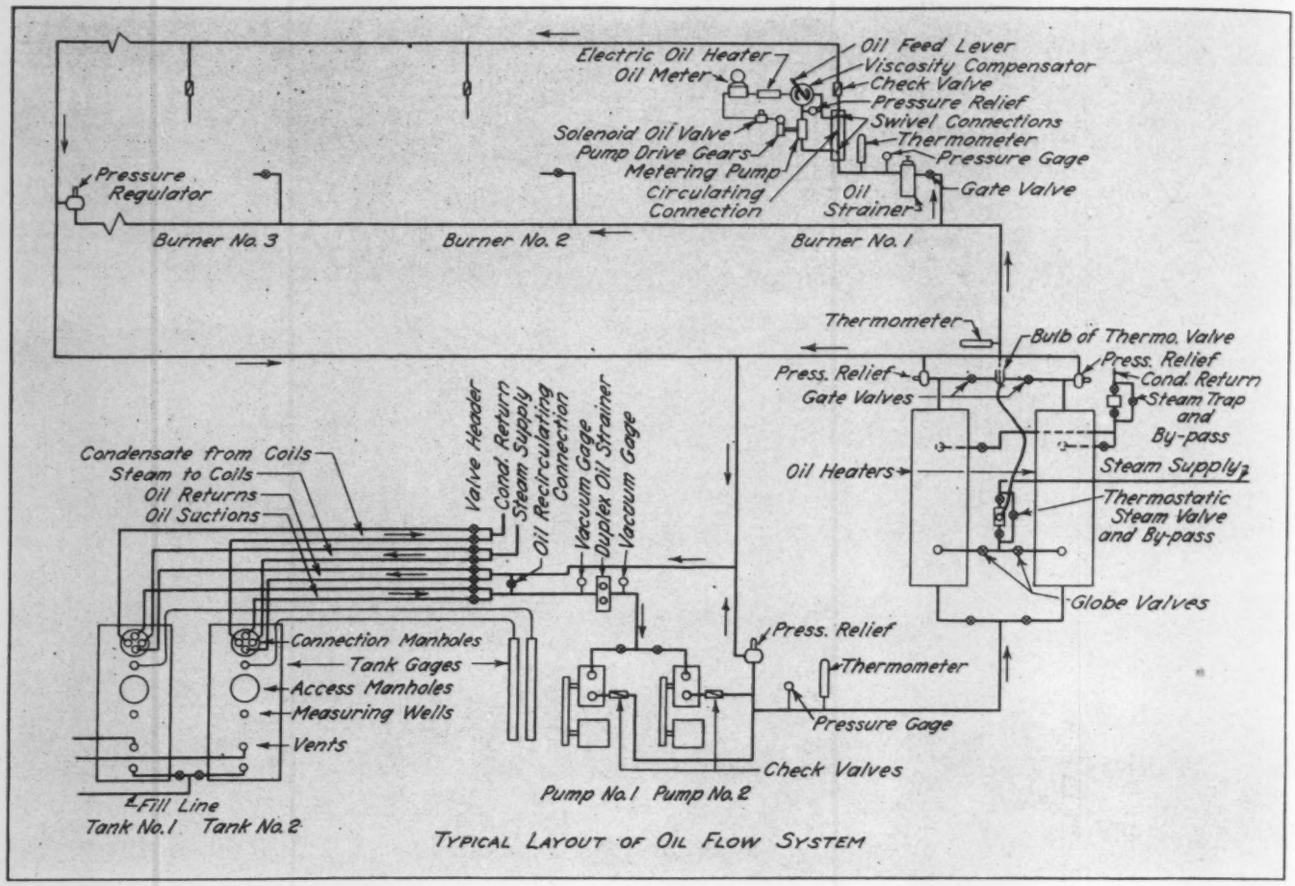


Fig. 3—Flow scheme for an oil burner installa tion having several burners using bunker C oil

lating pumps, and oil heaters. Oil in storage is maintained at whatever minimum temperature will assure easy suction to the circulating pumps—for average bunker C oil a suction temperature of 80 to 100 F will do. At the heater fuel oil temperature is raised to about 180 F, and is delivered to the individual burner pumps at a somewhat lower temperature, but not less than 160 F. An electric heater permits the burner to heat up that oil which may have cooled off in the burner piping while the burner was down. It should be noted that the electric heater raises the temperature only of that oil which has already been measured out for burning, and furthermore that this heating can have no effect upon the viscosity compensator. This complete arrangement will permit of full automatic operation of any number of burners without any great amount of attention from the plant operator other than cleaning of the atomizers and strainers.

AIR CONDITIONED INSPECTION ROOM

Brightly polished balls and rollers parade before keen eyes in the scientifically lighted and air conditioned inspection room in the Atlas Ball Div. of SKF Industries, Inc., manufacturers of ball and roller bearings. In this model room, girls wearing white gloves scan balls and rollers for surface defects with the same degree of visual concentration needed in detecting flaws and scratches on costly jewels. Gloves protect balls and rollers from moisture

Air Conditioned Chemistry Laboratory Does Its Part in Winning the War

Combination of Refrigeration and Silica Gel Allows Wide Range of Temperatures and Humidities . . . . By Lester T. Avery

SUMMARY—In one of the rooms in a chemistry laboratory building for an industrial plant engaged in war production, temperatures must be varied over a range from 68 to 86 F and relative humidities from 35 to 65 per cent. Air requirements of the exhaust hoods also complicate the problem. . . . The scheme used for air conditioning involves a refrigeration compressor for cooling, steam coils for heating, a pan type humidifier, and a silica gel machine for dehumidification—thus, separate control of temperature and humidity is provided. . . . Hunting of the room temperature curve on the heating cycle was corrected by using an anticipating type of control. . . . The author is head of Avery Engineering Co.

If you wanted to build a good chemistry lab, what would you do about air conditioning? Put it on the "must do" list of course, but then what?

Have you ever worked in a chemistry lab? Remember the smells? Well, the things you smelled were odoriferous fumes of chemicals which in themselves would set up chemical reactions with other materials or chemicals. So you first would insist that your laboratory have adequately ventilated hoods.

All the air to vent the hoods is *outside* air. When hoods are in full use that requires a lot of air. If hoods are not in use, why waste the conditioning on a surplus of air not needed for ventilation? So you design a system that will pick up extra exhaust and extra supply by throwing a switch when you need it—otherwise you use the minimum outside air at minimum operating cost.

Then maybe you want quite a range of temperatures for various experimental purposes. Dr. Muskat, director of the chemistry laboratory at the Columbia Chemical Div. of the Pittsburgh Plate Glass Co., wanted a temperature range—at his own discretion—from 68 to 86 F. He told Ed Wagner, his architect, and Ed told John Paul Jones, his consulting engineer, and Jones said, "O.K."

But Dr. Muskat also wanted a variable relative humidity, because humidity is sometimes as important in a chemical reaction as temperature. So Mr. Jones designed a system that would provide a variation in relative humidity from 35 to 65 per cent.

Then you see what immediately came up as the crux of the problem. Supposing you want to change your temperature without changing your relative humidity. Or on the contrary, do you wish to change the humidity without a change in temperature? What limitations shall be put on the available conditions due to *outside* temperatures? For example, if you carry too high a relative humidity and temperature

The air conditioned lab, showing the ceiling air diffuser and the wet and dry bulb temperature recorder. A conditioning system needs such a recorder as much as it does a thermostat

in severe cold weather, your *dew point* is too high and you get condensation on the walls and *in* the walls of the building itself. If you try to carry too low a dew point in hot sultry weather, you get too much vapor going through the walls. What reasonable limitations are to be put on the conditions available when the full exhaust is running for the hoods, thus requiring maximum outside air? These considerations caused Mr. Jones to prefer entirely separate control of temperature and humidity.

The System

In this case, Mr. Jones designed a system which handles simple cooling by a conventional direct expansion Freon-12 refrigerating machine, with heating supplied by steam coils. The dehumidifying is accomplished by a silica gel machine, gas reactivated, and the humidifying is done by boiling water by a steam coil in a pan type humidifier. Only one room is conditioned, so the control problem was relatively simple.

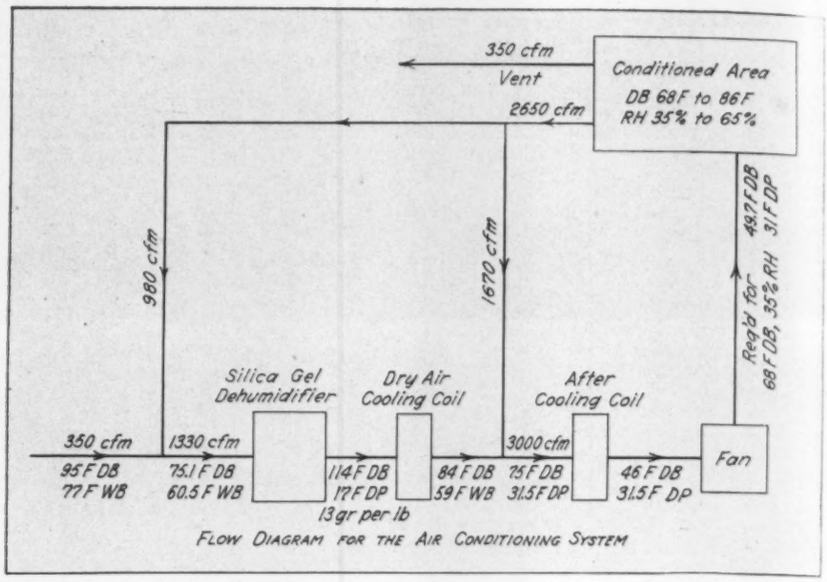
The air conditioned chemical lab is on the third floor of the laboratory building and has north, east and west exposures. The air conditioning equipment is tucked in the attic space directly above.

Note particularly—in the interior picture of the laboratory—the ceiling air diffuser for air distribution and the wet and dry bulb temperature recorder to tell the story of what goes on and exactly when. A conditioning system that has any technical importance needs a recorder as much as it does a thermostat.

Specifications

After Dr. Muskat had decided what compromises could be made with an eye to reasonable equipment and available space and funds, the following specifications were established:

The air conditioning equipment for this laboratory was designed to maintain any dry bulb temperature between 68 and 86 F with any relative humidity between 35 and 65 per cent when the outside condition is 95 F dry and 77 F wet bulb,



FLOW DIAGRAM FOR THE AIR CONDITIONING SYSTEM

with the equipment delivering 15 per cent outside air and when the hood exhaust fans are not running. It was also designed to maintain a winter condition of 72 F dry bulb and 30 per cent relative humidity when delivering 100 per cent outside air with an outside temperature of zero.

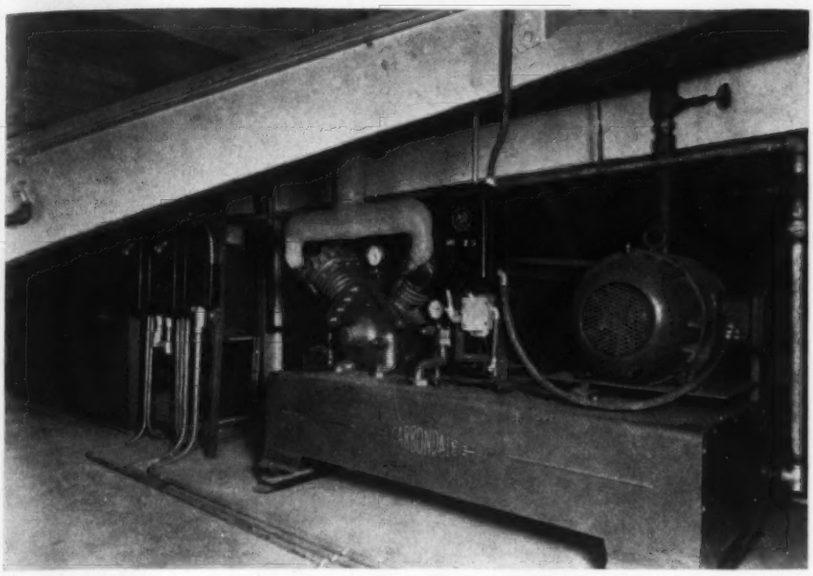
Interpreting these specs from a commonsense viewpoint meant simply that the extreme conditions would not be expected when the exhaust fans were running full capacity and when the outside air conditions were extreme. Ninety-nine per cent of the time, winter and summer, the system would do its tricks of temperature and humidity control. But comes the zero day in winter or the 95 F day in summer, *and* full ventilation; then you would be satisfied with less extreme inside conditions, within the limits of the apparatus.

A study of the flow diagram will show how the functions of separately controlling humidity and temperature are accomplished. When the switch is thrown to open up maximum exhaust, the maximum outside air damper is opened and the recirculating damper closed, so the system goes on full outside air. Normal operation requires a conditioned air unit handling 3000 cfm of which 2650 cfm is recirculated and 350 cfm is outside air. Under the full ventilating damper position, 3000 cfm of outside air is supplied and 2650 cfm is exhausted, thus leaving 350 cfm for exfiltration. (Pressure should be kept on a conditioned lab of this kind to minimize the effect of infiltration, although the equipment must be planned to take up infiltrated moisture to a certain extent. Data are badly needed for figuring infiltration moisture under various vapor pressure differentials and different wall constructions.)

Control Problem

The temperature recorder showed up a defect in the pneumatic control system that required special analysis to correct. Under the first requirement for heating the recorder showed a terrible hunt. At certain times during the day there would begin a regular sine wave of room temperature variations from 4 to 8 deg swing. Changing the sensitivity of the thermostat did not help. A recorder was put on the steam line and a variation in pressure was shown, jumping from 5 to 17 psi and that obviously started the heating to cycle.

Instead of installing a reducing valve (which was obviously indicated) to hold a constant steam pressure, having particularly in mind the tremendous increase in steam requirement when the exhaust fan was thrown on maximum and very little steam needed under normal circulation, we tried to do a little better job from a pure control engineering standpoint. This was accomplished by an "anticipating control", which consists of a supply duct thermostat, reset by the roomstat, so that as the room needs change, "permission is granted" to change the supply air



The refrigeration machine for cooling and the silica gel machine for dehumidifying are tucked into the attic space directly above the third floor laboratory room which they serve

to higher or lower temperatures.

The handle to this situation is that a quick demand for additional heat due to the exhaust going full blast, or a quick check being needed due to rise in steam pressure at the automatic valve, is held within reasonable supply air limits by this "anticipating" thermostat. It "anticipates" that if that air overruns, the room temperature itself will overrun and that will make a hunt as shown on the room temperature curve. Now you can throw the exhaust fan on or change the steam pressure 10 psi and turn the exhaust fan off and you get lovely room temperature curves that look like they were drawn with a compass.

To the engineer in charge of a chemical laboratory who wants to hold temperature and humidity and set points, a curve is really a straight line, or else. This laboratory's air conditioning equipment was designed to be that way and with this one small modification it now is that way.

ENGINEERING PROBLEMS IN AIR CARGO TRANSPORTATION

AN ENORMOUS increase in air cargo in the near future has been predicted by various authorities and many surveys have been made to analyze the markets which should develop. Little has been said about the actual engineering and mechanical problems involved in the handling of air cargo. It is true that several cargo plane designs have been evolved and proposed which include many novel construction features, but little has been available to designers in the way of operation and cargo handling recommendations.

In a recent paper on engineering problems associated with air cargo transportation, presented by R. D. Kelly and W. W. Davies of United Air Lines Transport Corp. at the national aeronautic meeting of the Society of Automotive Engineers, the authors indicated probable design and performance trends and outlined some of the specific problems of carrying air cargo. The background for the conclusions drawn was based upon an actual research study for cargo airplane performance and design criteria; present airline cargo handling experience, from which—according to the authors—it is apparent that present methods and equipment are wholly inadequate for any great extension; and opinion and imagination.

Following are the paragraphs on heating and ventilating cargo planes:

The need for good temperature control, ventilation, lighting and supercharging must not be overlooked by the designer; all of these items must be taken into account in the transport of cargo by air. The need for temperature control is already recognized because flowers, certain foodstuffs, birds, etc., must be protected against freezing. Other items need to be kept cool for preservation. This calls for adequate heating and possibly cooling equipment, the control of which must be automatic. Passengers and crew will complain if they are subjected to an uncomfortable temperature, but cargo is not so helpful.

Good temperature control requires the use of insulation and good ventilation. Airlines now have frequent difficulty with spoilage which results when perishable cargo is stored close to the skin of the fuselage and then covered with other cargo. Even though the air temperature of the compartment is kept above 32 F, the cargo may freeze when the airplane is flying at low temperatures. Likewise, cargo may become overheated when the airplane is standing in bright sunlight on a hot day. It should be noted that compartmentalization assists in avoiding this condition. Good ventilation is also necessary to eliminate odors, vapors, dampness, etc.

Supercharging at least a portion of the cargo space will be essential, particularly those spaces where birds or other living creatures may be carried, or where relatively fragile airtight containers will be stored, which are not capable of withstanding considerable atmospheric pressure differences. This statement is made in spite of the fact that many designers have believed that supercharging could be eliminated entirely in the cargo airplane. They should not forget that mountains must be crossed, storms have to be avoided and often high temperature conditions and rough air will force the cargo airplane to fly at approximately the same elevations utilized by the passenger airplane.

For news about new and improved equipment, see Equipment Developments in HPAC every month

"Open for Discussion"

GRAPHICAL ANALYSIS OF PERIODIC LOADS

THE EDITOR—

In their data sheet on Graphical Analysis of Periodic Loads in the April HPAC, B. F. Raber and F. W. Hutchinson have applied the Schmidt method, devised by Ernest Schmidt and published in Festschrift by August Foppls in 1924. Although it is an approximation, the method rests on a sound theoretical basis which is well presented in English by F. E. Giesecke in his paper on The Flow of Heat Through Walls, pp. 441-457, vol. 45, ASHVE Transactions, 1939.

The advantage of the Schmidt method is that it can be applied with reasonable accuracy to multiple layer walls. The disadvantage is that when Δx is taken small enough to give accurate results, the process is very laborious. For single layer walls, the more rigorous analysis is both more accurate and easier. In an excellent paper entitled Effect of Heat Storage and Variation in Outdoor Temperature and Solar Intensity on Heat Transfer Through Walls, Alford, Ryan and Urban give an analysis for single layer walls that is both more accurate and easier to apply than the Schmidt method, especially if a good harmonic analyzer is available. A similar solution for walls consisting of several layers is likely to prove so complicated that resort to the Schmidt method may become necessary, although there are also available electrical methods, one of which was described by Paschkis in the ASHVE Journal section of the February, 1942, HPAC.

Returning to the application of the Schmidt method made by Raber and Hutchinson, it should be noted that they did not take sun load into account. For the computation of a winter heating load where the maximum occurs early in the morning there seems to be no objection to this omission, but for summer cooling loads the effect of the direct radiation from the sun is so important that it must not be neglected. The inclusion of the sun load will require a modification of the Schmidt method but that should not be difficult.

Any of the methods available are too laborious for immediate practical use. To be useful they must be reduced if possible to tabular form that can be used with a minimum of computation. The next best thing would be charts that are not too difficult to read. A good start in this direction has been made in the ASHVE Heating, Ventilating, Air Conditioning Guide which gives tables of solar intensities and time lags, pp. 142-147 in the 1942 edition. The amount of labor that will probably need to be done is great but after the the war is over it should prove possible to make further fairly rapid progress by possible use of NYA labor and graduate students. The NYA boys can help pay their way through college by making some of the calculations and the graduate students can submit computations for certain walls as their masters' theses. The work can be carried on at a large number of different institutions but should always be under the supervision of somebody who has specialized in heat transmission. It may be possible to make fairly rapid progress on this much needed work if all the possible sources of labor are used, although it is highly desirable to secure fairly general agreement on the most promising procedures before too much work is done.—ELMER G. SMITH, associate professor of physics, Agricultural and Mechanical College of Texas.

THE EDITOR—

In the data sheet published in the April HPAC, Graphical Analysis of Periodic Loads, B. F. Raber and F. W. Hutchinson present a very interesting variation of the graphical method first published by E. Schmidt. However, a few remarks may be permitted:

1) In summer the knowledge of the ambient air temperature would be of little value without due consideration of the heat received from the sun by radiation; in fact, in many cases, the surrounding air will be heated, in summer, from the outside wall surface.

2) It is doubtful how accurately a sine wave represents the actual temperature time curve. The publications of the ASHVE research laboratory seem to prove that the curves are not sinusoidal.

3) Frequently the constant inside temperature is not equal to the minimum outside temperature. Then the broad applicability of a single solution is lost.

4) The amount of work necessary to carry out the determination is quite considerable, especially if the temperature gradients at more than one time are desired. It is surprising to read the statement (comment to Fig. 8) that in most cases one cycle is sufficient. That implies that in most cases the temperature distribution had been assumed correctly —in which case no graphical (or other) investigation would be necessary.

It is therefore felt that more cycles will be necessary. After having reached "cyclic equilibrium" one more cycle has to be drawn to determine the temperature history at other times than that of the start.

5) The film coefficients in many cases will not be constant.

In view of these difficulties and limitations, the writer feels that, under normal circumstances, the electric analogy method of analyzing such problems will yield results in shorter time and subject to fewer limitations.—VICTOR PASCHKIS, research associate, department of mechanical engineering, Columbia University.

HEATING AND PLUMBING DISTRIBUTORS COMMITTEE

The bureau of industry advisory committees of the War Production Board announced April 13 the formation of a distributors subcommittee of the plumbing and heating industry advisory committee. W. W. Timmis, chief of the plumbing and heating branch, is government presiding officer.

AIR IN CONTACT WITH WATER

Analyzing Air Conditioning and Heat Exchange Processes with the Psychrometric Chart . . . By William Goodman

THERE IS hardly a process in air conditioning in which air and water are not brought into direct contact with each other. Because air conditioning equipment so frequently involves direct contact of water and air, a thorough understanding of the action that takes place between the water and air can be very helpful in analyzing the performance of equipment and in understanding the operation of air conditioning systems. The psychrometric chart lends itself beautifully to the analysis of the action of air and water in direct contact with each other.

No attempt is made in this group of articles, of which this is the third and last, to analyze the performance of equipment. The action of air and water in direct contact with each other in different types of apparatus is explained so that the differences involved in various types of conditioning processes can be readily understood.

The discussion is continued from the April issue:

Various Processes

Heating and Humidifying with Water Whose Temperature Varies

Curves *A* of Figs. 6 and 7 [pp. 238-239, April HPAC] represent the heating of air with water whose initial temperature lies between the initial dry and wet bulb temperatures of the air. In Figs. 10 and 11 the initial temperature of the water is greater than the initial dry bulb temperature of the air. The parallel flow curve of Fig. 10 is approximately applicable to the commonly used air washer in which the flow of water and air are almost parallel to each other, and in which the water is heated as it circulates through the piping outside of the washer. The condition curve shown in Fig. 11 is applicable to the commonly used, vertical type induced or forced draft cooling tower in which the flow of water and air are counterflow to each other. In Fig. 11 the final water temperature is shown at a point higher than the initial dry bulb temperature of the air. In the usual cooling tower, sufficient air is provided so that the final water temperature is usually at some point between the initial dry and wet bulb temperature of the air. Curve *A* of Fig. 7 is representative of a counterflow cooling tower in which the water is cooled to a temperature between the initial dry and wet bulb temperatures of the air. It is, of course, possible for water initially at a temperature higher than the initial dry bulb temperature of the air to be cooled to a final temperature between the initial dry and wet bulb temperature of the air.

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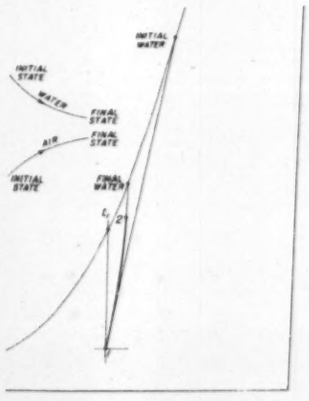
Fig. 10—Simultaneous heating and humidification of air in parallel flow with water whose temperature varies



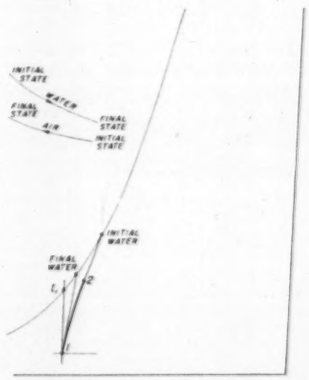


Fig. 11—Simultaneous heating and humidification of air in counterflow with water whose temperature varies

SUMMARY—Processes in which air and water are brought into direct contact with each other are quite common in air conditioning; familiar examples are air washers, cooling towers and evaporative condensers. The condition of the air as it passes through such equipment can be represented either by a curve or straight line on the psychrometric chart. Such a curve is known as a "condition curve," because any point on the curve represents the condition of the air at various stages in the process. . . . There is presented in the group of articles of which this is the third and last, the method of determining the state of the air while it is in contact with the water. Typical condition curves for a number of common processes are presented and discussed. A thorough understanding of the condition curves for various types of apparatus will be of considerable value to those who design air conditioning systems. . . . The author is consulting engineer, the Trane Co., and a member of HPAC's board of consulting & contributing editors

Cooling and Humidifying with Water Whose Temperature Varies

Condition curves representing the cooling and humidifying of air by direct contact with water are illustrated by the curves marked *A* in Figs. 6 and 7. Comparing these curves with those in Figs. 10 and 11, it is apparent that for cooling and humidifying, the curves lie wholly to the left of the almost vertical line of dry bulb temperature, whereas for heating and humidifying, they lie wholly to the right.

Condition curves *A* in Figs. 6 and 7 illustrate the case in which the initial temperature of the water is above the initial wet bulb temperature of the air. It is also possible to cool and humidify air with water whose initial temperature is below the initial wet bulb temperature of the air. This case is illustrated in Fig. 12 for parallel flow and in Fig. 13 for counterflow. For the cases illustrated in Figs. 12 and 13, both the initial and final temperatures of the water lie between the initial wet bulb and dew point temperatures of the air.

Theoretically, air can be humidified even if the initial temperature of the water is *lower* than the initial dew point temperature of the air.

However, if the air is to be humidified, the *final* temperature of the water must be *higher* than the initial dew point temperature of the air. In this case, the condition curve for parallel flow will appear as in Fig. 14, and for counterflow as in Fig. 15. In these figures, point 2 on the condition curve representing the final state of the air

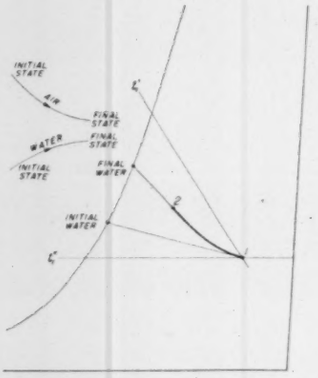


Fig. 12—Simultaneous cooling and humidification of air in parallel flow with water whose temperature varies

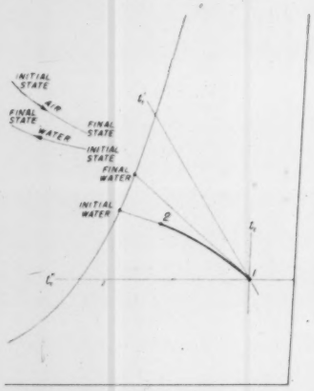


Fig. 13—Simultaneous cooling and humidification of air in counterflow with water whose temperature varies

can lie either above or below the horizontal line representing the initial dew point temperature of the air. Whether the final condition of the air will lie above or below the initial dew point temperature of the air depends upon the characteristics of the conditioning apparatus and upon the quantity of water supplied.

Cooling and Dehumidifying with Water Whose Temperature Varies

The curves marked *B* in Figs. 6 and 7 [pp. 238-239 April HPAC] illustrate the cooling and dehumidifying of air by direct contact with water. For these curves, both the initial and final temperatures of the water are lower than the initial dew point temperature of the air. In these illustrations, the entire condition curve *B* for the cooling and dehumidifying process lies below the horizontal line representing the initial dew point temperature. If sufficient water is provided so that the final temperature of the water is lower than the initial dew point temperature, the air will always be dehumidified; it cannot be humidified.

In any apparatus in which the water is in direct contact with the air, sufficient water should always be provided so that under the heaviest heat load the final temperature of the water will be lower than the initial dew point temperature of the air. How much lower depends upon the required final dew point temperature of the air.

Theoretically, air can be dehumidified even if the final temperature of the water is above the initial dew point temperature of the air. In this case, the condition curve for parallel flow will appear as in Fig. 14, and for counterflow as in Fig. 15. With such condition curves, it is difficult to determine whether point 2 representing the final state of the air will lie above or below the initial dew point temperature of the air. This depends upon the characteristics of the conditioning apparatus. In actual installations sufficient water should be supplied so that the final temperature of the water can never rise above the initial dew point temperature of the air.

The curve marked *B* in Fig. 7 is also similar in appearance to condition curves that are obtained for counterflow when the cooling water and air are separated from each other by a metallic surface. This is the case in cooling coils in which the air flows past the outside surface of the tubes and the cooling water flows inside the tubes of the coils. If the air is being dehumidified by a coil, the outside surface in contact with the air will be covered with a film of water condensed from the air. This condensate, which forms the surface film of water, should not be confused with the cooling water inside the tubes. The air is, of course, actually in direct contact with the surface film of water and not with the cooling water inside the tubes. The temperature of the surface film of air is the same as the temperature of the surface film of water. The temperature of the water flowing through the tubes of the coil is always lower than the temperature of the surface film. At any point on the surface of the coil, the temperature of the surface film of water is at some temperature between the wet bulb temperature of the air flowing past the coil and the temperature of the water inside the coil at that particular point on the

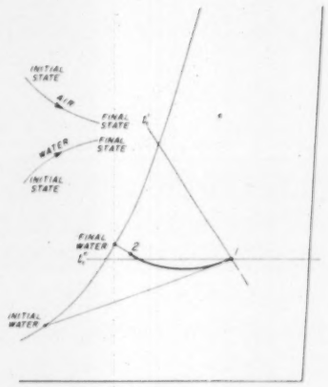


Fig. 14—Air can be humidified even though initial temperature of water is lower than initial dew point temperature of air. Parallel flow is illustrated

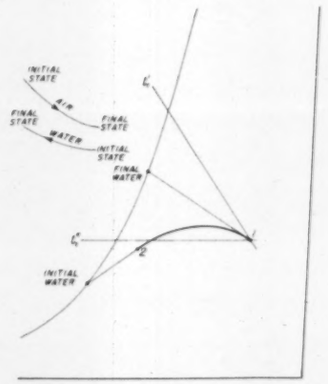


Fig. 15 — Air can be humidified even though initial temperature of water is lower than initial dew point temperature of air. Counterflow is illustrated.

cooling surface. [The method of computing the temperature of the surface film of water has been described in HPAC, June, 1941, p. 359.]

Obviously, dehumidification of air can occur only if the temperature of the surface film of water is lower than the initial dew point temperature of the air. In turn, the temperature of the surface film of water can be lower than the initial dew point temperature of the air only if the temperature of the metal coil itself has been chilled by the cooling water to a temperature that is also lower than the initial dew

point temperature of the air; if the temperature of the metal is higher than the initial dew point temperature of the air, then obviously no condensation of moisture from the air can occur and the metal surface will be dry.

In a counterflow coil, if, as a result of an insufficient supply of cooling water, the final temperature of the water is too high, a portion of the outside surface of the coil may be dry. In this case, cooling of the air will at first take place along the line of constant initial dew point temperature as in Fig. 16. De-

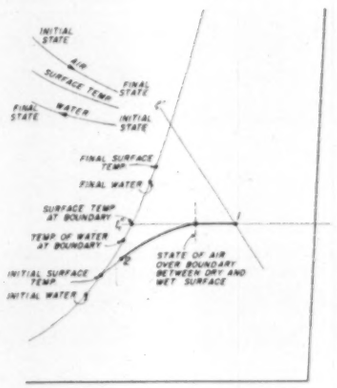


Fig. 16—Condition curve when air is cooled by water inside of coil and an initial portion of coil is dry. Also see Fig. 17

humidification of the air cannot immediately begin at the inlet of the coil; dehumidification can begin only at the point where the temperature of the water is sufficiently below the

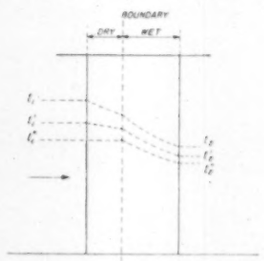


Fig. 17—Cooling coil with dry and wet surfaces. Also see Fig. 16

initial dew point temperature of the air so that the temperature of the surface film of water is also lower than the initial dew point temperature of the air. From this point on, the condition curve will drop as the air is cooled and dehumidified as shown in Fig. 16. The change in the state of the air as it flows through a coil, part of which is dry and part wet, is also illustrated in Fig. 17 which should be studied in conjunction with Fig. 16. [The method of constructing the curve illustrated in Fig. 16 and of computing the state of the air as it passes over the boundary between the wet surfaces of the coil has been discussed in HPAC, November, 1938, to May, 1939.]

A comparison between the condition curves of Figs. 15 and 16 is of interest. The curve of Fig. 15 is drawn for direct contact of the air and cooling water in counterflow. In this case, if the final temperature of the water rises above the initial dew point temperature of the air, the air will at first be humidified. On the other hand, in Fig. 16, for which the air and cooling water are separated by a metallic surface, the dew point temperature of the air will not change as it flows over the portion of the coil where the temperature of the water is higher than the initial dew point temperature of the air.

For the cooling and dehumidifying of air by counterflow coils, the condition curve will always bend downward as in Figs. 7 and 16. However, for parallel flow coils, the condition curve can bend either downward or upward. [This has been discussed in HPAC, June, 1941, p. 359.]

A thorough understanding of the various types of condition curves for different processes will frequently prove of value in analyzing air conditioning cycles. In this article it has been possible to touch only on typical condition curves for several different processes. However, the broad fundamentals have been outlined in sufficient detail so that further study of the various references mentioned will provide the reader with enough information to enable him to construct his own condition curves.

Symbols

t_1 = initial temperature of water supplied to conditioning apparatus, F;
t_2 = final water temperature, F;
t' = wet bulb temperature, F;
t'' = dew point temperature, F.

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WHY A CLOSE NIPPLE IN THE HARTFORD LOOP?

THE EDITOR—

Will you please inform me why magazines and reference books advise the use of a close nipple in the return main where a Hartford loop joins the tee on the balance pipe? It is clearly stated to use a close nipple, but without explaining why. Any information you may give me will be greatly appreciated.

—H. C. B.

REPLY—A *close* nipple is recommended in an underwriters loop or Hartford loop in the horizontal connection between the riser from a wet return main and the vertical balance pipe connecting the steam outlet and return inlet of a boiler, for the following reason.

The loop connection will be just as satisfactory if this horizontal nipple is "short" instead of "close" and the operation will be essentially as safe if the horizontal nipple is anywhere between "close" and two or three feet long provided the pipe is not excessive in size. The reason for the "close" stipulation was to safeguard against the use of a long horizontal pipe at this point. A long return pipe of considerable size placed so close to the water line that it might sometimes be full of water and at other times be nearly empty of water could promote objectionable differences in boiler water level.

A fundamental of good steamfitting practice is never to have a dry return which under heavy heat demand might become wet, or to have a wet return which might become dry. Failure to observe this fundamental has caused many broken sections in cast iron steam boilers. If this short nipple of the Hartford loop which normally is full of water, is a long pipe, and if pressure fluctuations at either the boiler end or the condensing end cause it to be dry, objectionable variations in the boiler water level could follow, since the large volume of water contained within the pipe could be held back in the remote heating surfaces by a very small pressure difference.—SAMUEL R. LEWIS, consulting mechanical engineer; member of HPAC's board of consulting & contributing editors.

CODE FOR PRESSURE PIPING

SECTION 6 —FABRICATION DETAILS

By Ludwig Skog, Chairman, Subcommittee on Fabrication Details; Partner, Sargent and Lundy

SUMMARY—Since the American Standards Association code for pressure piping (B31) was first issued as a tentative standard in 1935, there have been many developments and advances in piping practices, as described by Sabin Crocker in the January HPAC in the first of a group of articles, of which this is the fifth. The piping code has been thoroughly revised and is being reissued as a full American standard. Section 1 of the new code, on power piping, was reviewed by Alfred Iddles in the February HPAC. In March, the section on gas and air piping was covered by John S. Haug, and the section on oil piping systems was analyzed by A. D. Sanderson. Last month, the code sections on district heating piping, and on refrigeration piping (including air conditioning) were reviewed by G. K. Saurwein and A. B. Stickney. . . . This month, part of the section on fabrication details is discussed by Mr. Skog, who will complete the subject in June

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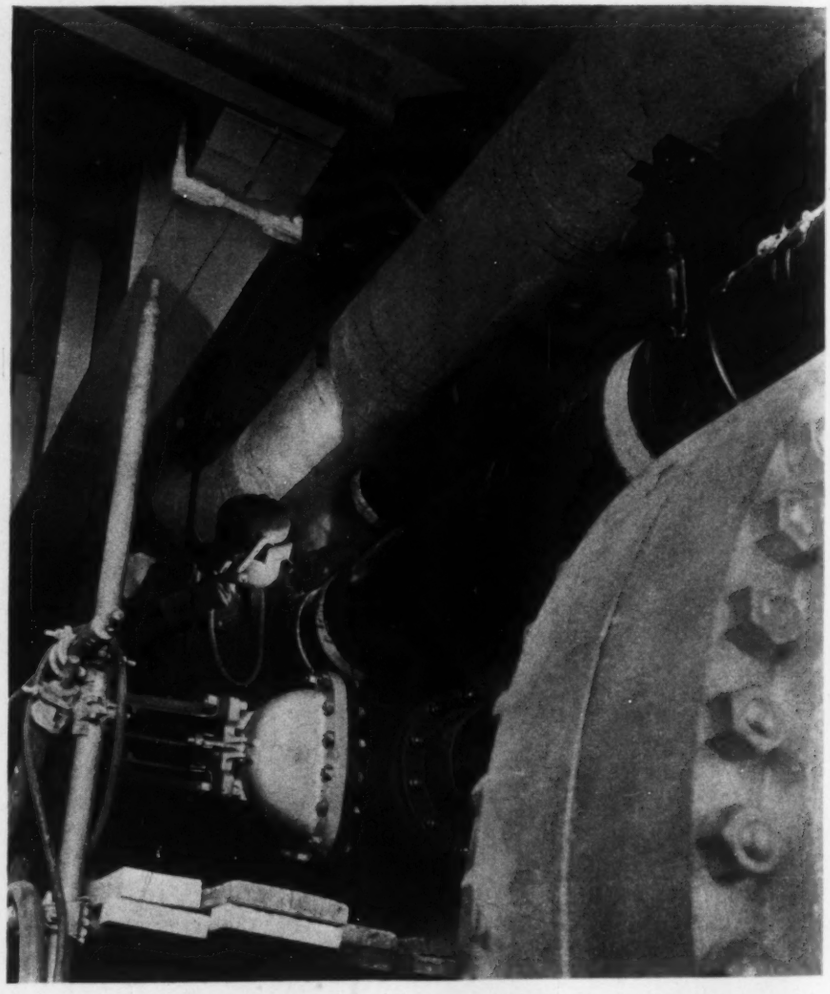
SECTION 6 ON fabrication details of the new ASA code for pressure piping is intended to provide a set of minimum requirement standards covering the fabrication of equipment constituting pressure piping installations within the scope of this code. Chapter 1 deals with the equipment which regulates the motion of and supports the piping of these systems; chapter 2 deals with the fabrication of pipe joints other than welded joints; chapter 3 deals with the approved methods of providing for the thermal expansion of piping and the flexibility of piping systems; chapter 4 deals with the preparation of parts for welding, the making and testing of welded pipe joints and the testing of welding processes and operators; and chapter 5 deals with the fabrication and welding of branch connections. Chapters 1 and 2 have been revised only slightly; chapter 3 contains new and comprehensive rules for figuring flexibility of pipe lines; chapter 4 has been completely revised; and chapter 5 is entirely new in this issue of the code.



Welding a 16 in. carbon steel steam line connecting a turbogenerator and an extraction feedwater heater

Hangers, Supports, Etc.

The general limitations of this chapter have been restated and broadened somewhat to provide more complete requirements. It is stated that supports shall be such as to prevent in operation, excessive stresses, excessive variation of supporting effort and possible resonance with imposed vibrations. The construction shall also be such that complete release of the piping load will be impossible in the case of spring failure or misalignment.

The matter of providing sufficient support to avoid resonance with imposed vibrations is important, particularly for piping used in power plants in connection with high speed turbogenerators where vibration problems have been more severe. Where necessary, therefore, the code now requires that nonresonant supports supplemented by energy absorbing means in the supports themselves or in auxiliary

equipment such as sway braces or vibration dampeners shall be used to reduce the effect of vibration on piping associated with turbines, or elsewhere if severe vibration of pipe lines is encountered.

Hangers, supports, etc., in general are required to be designed using a factor of safety of five based on the ultimate tensile strength of the material at room temperature. Where metal temperatures exceed 650 F, and particularly at the higher temperatures where creep is important, tensile strength is, of course, unsuitable as a basis for design. Accordingly, it is stated that if any part of the supporting equipment is intended for operation at 650 F or higher, the calculated stress shall not exceed the values of allowable stress given in the several sections for the type of material used at the particular temperature involved.

In the previous issue of the code, no provision was included in this chapter for the attachment of hanger supports by welding to the pipe line. It is common practice now to attach lugs by welding directly to the pipe, which may be used as supports for hangers or sway bracing. This type of attachment is permitted in the ASME boiler code. One type of welded hanger clip is shown in the accompanying sketch. Rules for such attachments are now designated as follows:

Lugs, plates, angle clips, etc., used as a part of a hanger assembly for the support of pipe may be welded directly to the pipe provided the design is adequate for the load. Welded joints shall be proportioned so that the stresses caused therein by the pipe loading shall not exceed the following values: shear on the section through the weld throat, 13,600 psi; tension on the section through the weld throat, 15,600 psi; and compression on the section through the weld throat, 18,000 psi. Welding shall be done by operators qualified in accordance with the rules of chapter 4 of this section.

Pipe Joints Other Than Welded

This chapter outlines specific requirements for threaded joints and the more common type of flanged joints. Special joints are expressly permitted, including sleeve or gland type, rubber or flexible rings held tight by pressure and properly retained, hub and spigot, screwed or flange union connections, flared and compression type joints and any other connections the joints and materials of which are suitable for the service conditions encountered as required by other sections of the code.

Joints for nonferrous pipe, not covered in the previous edition, are provided for in detail as follows:

Valves, fittings and flanges may be attached to nonferrous pipe and tubing by the following methods, and may be used at pressures and temperatures permitted by this code for the pipe or tubing unless otherwise specified:

1) By threading when the pipe is made to iron pipe size dimensions.

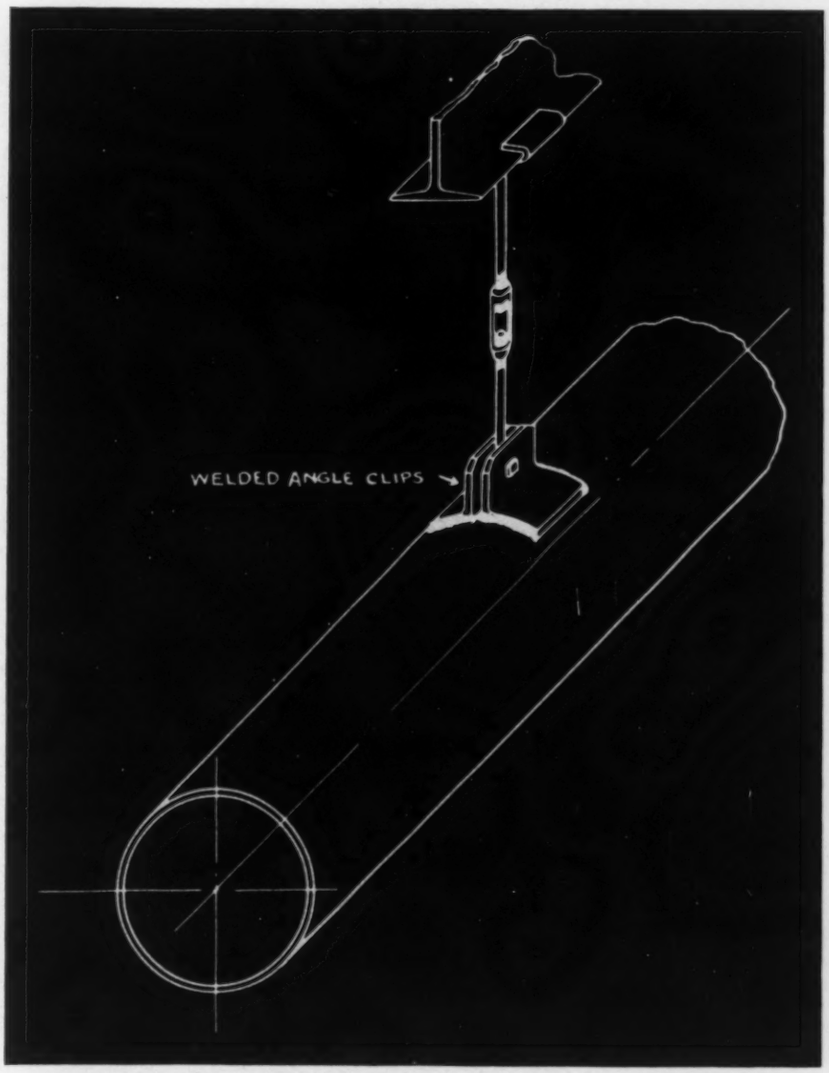
2) By flanged or lapped connections. Flanged connections may be made by expanding the pipe or tubing into grooves in the flange hub with the pipe or tubing end flanged over into a recess in the flange face, or by inserting the pipe or tubing into the flange and beading the end of the pipe or tubing over into a recess in the face of the flange.

3) By socket sleeve type joints using a brazing solder in which the copper plus silver shall not be less than 60 per cent. The brazed junction between pipe and sleeve shall extend the full depth of the socket. Fillet brazed joints are not acceptable.

4) For service temperatures of 250 F and less, joints of the socket sleeve type, in accordance with American standard soldered joint fittings (ASA A40.3), may be used for pressure and temperature ratings therein specified.

5) Flared or compression type connections may be used for pressures for which they are suitable.

Welding Flanges — Compatible with the increased importance attached to welding as a means of erecting pipe lines, new requirements for welding type flanges have been included to provide for welding neck and slip on welding flanges. Welding neck flanges may be used



Illustrating the use of welded hanger clips on power piping

in all sizes for pressures 2500 psi and lower as established in ASA B16e. Slip on welding flanges are permitted also in all sizes and for pressures and temperatures as established in ASA B16e. In the latter case, however, dimensions are established only for the 150 and 300 lb pressure standards so that slip on welding flanges are effectively limited to the 300 lb standard. It should be recognized, however, that this is a nominal limitation only since the adjusted pressure-temperature tables of ASA B16e permit higher pressures at lower temperatures. At 100 F, for instance, a 300 lb carbon steel, slip on flange could be used for 500 psi pressure service.

Flange Facings—It frequently is desirable to bolt a cast iron flange together with a steel flange as in the case of the cast iron flange on a pump casing, for instance, mating with a steel welding neck flange. Since cast iron flanges are provided with a plain face or a face extending to the inner edge of the bolt holes, and the steel flanges are furnished with a narrower raised face, an undesirable bending moment is created on bolting the two together which frequently results in breaking the cast iron flange. To warn against this practice, the following note has been included in this issue of the code:

In all cases where class 125 or class 250 cast iron flanges are used as one-half of a joint, the other half of which is a steel flange with a raised face, carbon steel bolts only should be used as there is danger of cracking the cast iron flange if alloy steel bolts are employed. Good design indicates that where a cast iron flange is bolted to a steel flange it is better to use a flat faced steel flange and a full face gasket. In such a joint alloy steel bolts may properly be used.

In the case of the raised face, or the male and female type of facing, provision is included to permit use of metallic gaskets having a width less than that of the standard face. Thus a higher unit compression may be secured on the gasket to permit proper seating of the gasket without overstressing either the flanges or bolts. The fact that the joint is made tight with lower stresses in the bolts and flanges favors maintenance of a tight joint through lower creep at the higher temperatures.

Expansion and Flexibility

Numerous methods of computing the flexibility of pipe lines have been published during the past several years and are available in the ASME Transactions and elsewhere. In view of the many variables involved in any of these methods, it was felt that in this issue of the code, more complete rules regarding computation of flexibility of piping should be included. While formal calculations need be made only where reasonable doubt exists as to adequate flexibility of the system, calculations —where necessary—shall be made in both the hot and cold conditions. The latter was considered essential, because where pipe lines are cold sprung more than 50 per cent, the resulting stresses may often represent the most critical condition.

Limits are designated for the maximum combined stresses due to bending and internal pressure as not to exceed three-fourths the sum of the S value for the piping material at atmospheric temperatures and the S value at the nominal operating temperature, but not to exceed 40 per cent of the tensile strength. This is a more or less arbitrary relation devised to provide stresses which are known to represent safe practice. In this connection, it should be remembered that allowable stresses vary between the different sections of the code.

Provision also has been made for piping which is subject to temperature variations of a definite cyclic nature, or to severe vibration which may result in failure by fatigue. For certain process piping, temperature variations comprise part of the cycle of operations, whereas discharge lines from reciprocating pumps or compressors may be subjected to severe vibrations. In these cases, the limit for safe combined stress mentioned above shall be divided by two.

The new rules on piping flexibility are quoted from paragraph 620:

c) In calculating the flexibility of a piping system between anchor points, it shall be considered as a whole and all parts, straight as well as curved, shall be considered as subject to flexure and stress. Calculations shall take into account the steady load stress concentrations or intensification factors found by test to exist in pipe bends, whether plain, creased or corrugated, and in corrugated straight sections. Credit may be taken for the extra flexibility of such members where flexibility factors have been determined from test data. Moments of inertia of straight pipe shall be based on the nominal dimensions of the pipe.

d) In calculating the total expansion, not only the expansion of the line itself but also movements of the equipment to which it is attached shall be considered.

e) In order to modify the effect of expansion and contraction, runs of pipe may be cut short and sprung into place. Where provision is made to assure that the designed cold spring actually is obtained, two-thirds of this amount may be considered as reducing the total expansion. While piping may be cold sprung more than half its computed expansion, the maximum credit allowed shall not exceed one-third the computed total expansion. The full amount of the cold spring shall be taken into account, however, in considering the forces, moments and stresses acting in the cold condition.

f) Calculations shall be made for both the hot and cold conditions, using the respective values of the modulus of elasticity of the pipe material for the hot and cold conditions.

g) Where a piping system is subjected to the occasional temperature changes and to combinations of constant stress and minor cylic variable stresses associated with the normal operation of plant, the combined stresses due to bending and pressure shall not exceed three-fourths the sum of the S value for the piping material at atmospheric temperature and the S value at nominal operating temperature, but in no case shall the combined stress due to bending and pressure exceed 40 per cent of the specified tensile strength of the pipe material at room temperature.

The longitudinal pressure stress shall be determined by dividing the end force due to internal pressure,

$$F = \frac{p \pi d^2}{4}$$

by the cross-sectional area of the pipe wall,

$$A = \frac{\pi}{4}(D^2 - d^2),$$

in which p = internal pressure, psi; d = nominal outside diameter of the pipe minus two times the nominal wall thickness, in.; D = nominal outside diameter of pipe, in.

h) Where a piping system is subject to temperature changes of a definitely cyclic nature or to severe vibration that may result in failure by fatigue, the limit of the safe combined stress permitted in paragraph (g) shall be divided by two.

i) Vertical lines shall be so designed that as actually installed and supported they allow proper pitch for draining the adjacent horizontal lines when hot.

Heating · Piping and Air Conditioning

AMERICAN SOCIETY of HEATING and VENTILATING ENGINEERS

Journal Section

War Service Committee

President Eastwood has announced the appointment of a War Service Committee, the functions of which will be to study the relationship of the Society, its activities and personnel to the war effort, and to coordinate our objectives with Government agencies desiring engineering assistance in the heating, ventilating, air conditioning field.

The Committee held its organization meeting in Washington, D. C., April 18. The Committee personnel consists of: Prof. B. M. Woods, University of California, Berkeley, Calif.; Brig.-Gen. W. A. Danielson, Memphis, Tenn.; W. L. Fleisher, Consulting Engineer, New York, N. Y.; E. Holt Gurney, President, Gurney Foundry Co., Ltd., Toronto, Ont., Canada; Thornton Lewis, Principal Production Engr., U. S. Army Ordnance, Washington, D. C.; Dr. A. C. Willard, President, University of Illinois, Urbana, Ill.

B. M. Woods, *Chairman*
Berkeley, Calif.

A. C. Willard
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E. Holt Gurney
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Thornton Lewis
Washington, D. C.

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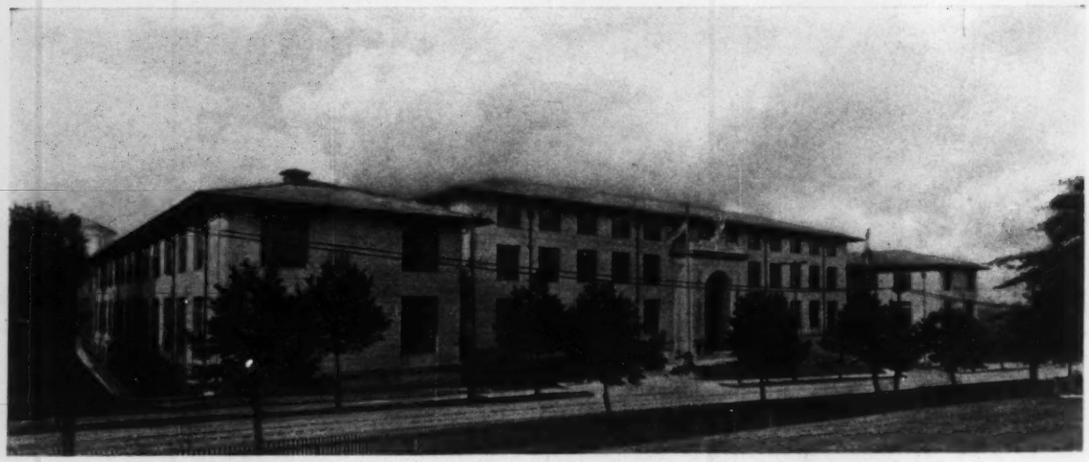

Pittsburgh Experiment Station of the U. S. Bureau of Mines where the Research Laboratory of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS is located

Heat Gain Through Walls and Roofs as Affected by Solar Radiation

By F. C. Houghten,* E. C. Hach,** S. I. Taimuty,*** and Carl Gutberlet†, Pittsburgh, Pa.

SUMMARY—Design heat gain rates for 11 walls and 18 roofs at various orientations are reported in this paper based on experimental observations conducted in an 18 x 18 x 8 ft high exposed cubicle. Results indicate that with minor variations the heat flow through east, south and north walls was 83, 75 and 46 per cent, respectively, of that for the west wall

HEAT GAIN through walls to summer cooled and air conditioned space is complicated by the wide cyclic variation in the outside air temperature and sun intensity. This is very marked when compared with the relatively constant flow through the same walls from a winter heated and air conditioned space.

When applied to winter heating the design outside temperature is likely to be as low as zero with a daily fluctuation of approximately 10 deg, whereas that maintained indoors would be 70 F or higher, giving a daily variation of about one-seventh of the temperature difference motivating heat flow through the wall. In summer cooling the design outside air temperature will vary with the locality over an approximate range of from 90 to 105 F with 95 as a good average for most metropolitan areas. With an inside maintained dry-bulb temperature of 75 F or higher, this gives a motivating temperature difference of 20 deg or less which usually fluctuates by more than this difference; that is, the outside air temperature at night usually falls below that maintained indoors. Solar radiation is a powerful factor in further affecting a wide cyclic variation in the heat flow through a wall during the summer, while in winter it has a relatively smaller effect and then tends to diminish rather than increase the magnitude of the heat flow. Hence, while it is relatively satisfactory to use simple transmission coefficients or U values applying to steady state flow for winter heating, such factors and assumptions cannot be used with safety for summer cooling calculations.

Several papers[1, 2, 3] resulting from work carried on at the Research Laboratory of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS have served to bring out this fact. By 1939 these studies had made it sufficiently obvious that the generally accepted winter heat flow coefficients could not be applied to summer cooling, to bring about the organization of a study planned by the Technical Advisory Committee on Cooling Load in Summer Air Conditioning[4] and aimed to make available the necessary data for calculating such gains. An 18 ft x 18 ft x 8 ft high cubicle,[5] was built, in which the simultaneous rates of heat gain through three different walls, having three or four orientations, and nine horizontal roof decks could be studied. A brief report[6] covering certain phases of the study, dealing with sprinkled

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†Assistant Research Engineer, ASHVE Research Laboratory.

Presented at the 48th Annual Meeting of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, Philadelphia, Pa., January, 1942.

[1] Heat Transfer through Roofs under Summer Conditions, by F. C. Houghten and C. G. F. Zobel. (ASHVE TRANSACTIONS, Vol. 34, 1928.)

[2] Heat Transmission as Influenced by Heat Capacity and Solar Radiation, by F. C. Houghten, J. L. Blackshaw, E. M. Pugh, and Paul McDermott. (ASHVE TRANSACTIONS, Vol. 38, 1932.)

[3] The Effect of Solar Radiation on the Heat Transmission Through Walls, by F. C. Houghten, Carl Gutberlet, and Albert A. Rosenberg. Symposium on Thermal Insulating Materials, March 8, 1939. (*American Society for Testing Materials*, Philadelphia, Pa.)

[4] C. M. Ashley, *Chairman*: John Everetts, Jr., E. H. Hyde, C. S. Leopold, C. O. Mackey, R. M. Stikeleather, J. H. Walker, W. E. Zieber.

[5] Summer Cooling Load as Affected by Heat Gain Through Dry, Sprinkled and Water Covered Roofs, by F. C. Houghten, H. T. Olson and Carl Gutberlet. (ASHVE TRANSACTIONS, Vol. 46, 1940.)

[6] Loc. Cit. See Note 4.

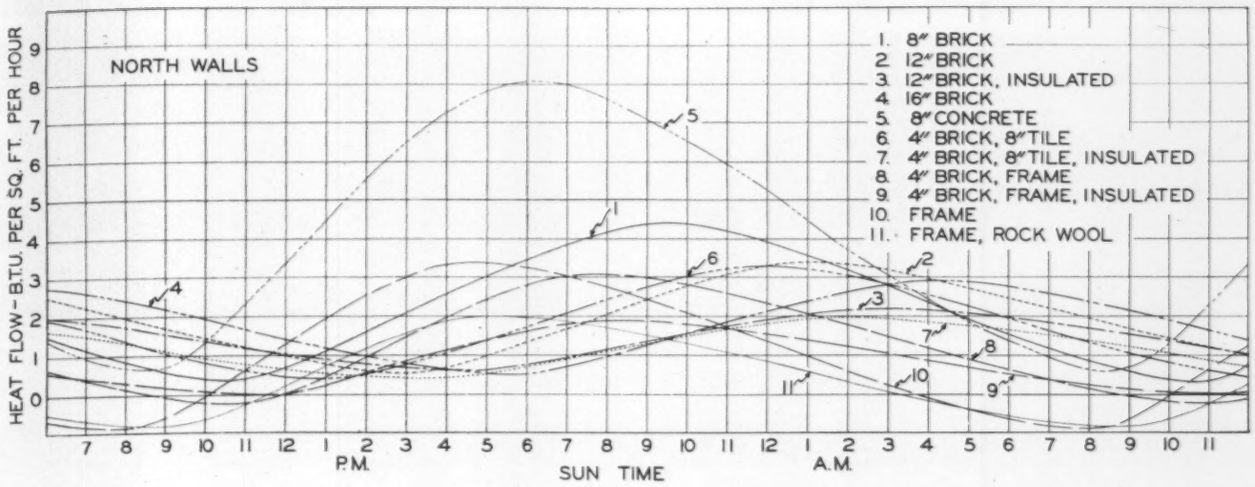

Fig. 1—Heat flow-time relationship for northern exposed walls

and flooded roofs was presented in 1940 and the results of further studies in this cubicle are given in this report.

Design Data for Walls and Roofs Studied

The original cubicle contained 5½ ft wide x 7 ft high wall sections of 12 in. brick and plaster and 4 in. brick, 8 in. hollow tile and plaster, facing north, east, south and west, and a third section of 4 in. brick and frame veneer with all but the northern exposure, gave a very satisfactory direct comparison of the time—heat flow relationships for the same wall on different exposures. During the summer of 1941 the work was continued with some of the original walls replaced by others, but not giving the direct comparison for different orientations. It is believed, however, that the facts learned in connection with the original walls make it possible to establish the time—heat flow relationships for different exposures when that for one exposure is known. Tables 1 and 2 give the construction, orientation, re-

Table 1—Construction, Resistance to Heat Flow, and Heat Capacity of Walls and Orientation in Which They Are Tested

Wall No.	Construction	Orientation 1940	Orientation 1941	*U* Btu per Sq Ft per Hour per Deg F Air Temp. Diff.	Heat Capacity Btu per Sq Ft per Deg F
1	8 in.[a] Brick, Plaster[b]	.....	E	0.46	15.87
2	12 in.[a] Brick, Plaster	N, E, S, W	N, E	0.34	23.38
3	12 in. Brick, Furring Space[c], 1 in. Structural Insulation Board, Plaster	.....	S	0.14	23.78
4	16 in.[a] Brick, Plaster	.....	E	0.27	31.80
5	8 in. Concrete[e]	.....	W	0.69	23.22
6	4 in. Brick, 8 in. Tile, Plaster	N, E, S, W	N	0.33	16.37
7	4 in. Brick, 8 in. Tile, Furring Space, 1 in. Structural Insulation Board, Plaster	.....	S	0.14	16.77
8	4 in. Brick, Wood Sheathing,[c] Stud Space,[d] Metal Lath, Plaster	E, S, W	.....	0.28	8.31
9	4 in. Brick, Wood Sheathing, Stud Space, 1 in. Structural Insulation Board, Plaster	.....	S	0.15	8.71
10	Wood Siding[f] Paper, Wood Sheathing, Stud Space, Metal Lath, Plaster	.....	W	0.26	2.79
11	Wood Siding, Paper, Wood Sheathing, Stud Space Filled with Rock Wool Insulation, Metal Lath, Plaster	.....	W	0.072	3.75

[a] Thickness of brick not including mortar, outside surface red mingled textured face brick.
[b] Plaster applied to brick, tile, and structural insulation board, consisted of ground coat and white skin coat ½ in. thick; when applied to metal lath ground coat and skin coat, ¾ in. thick.
[c] Actual thickness, 15/16 in.
[d] Actual thickness, 3⅝ in.
[e] Poured concrete with rubbed surfaces, inside and outside.
[f] ¾ in. x 8 in. lap siding, painted white.

Table 2—Construction, Resistance to Heat Flow and Heat Capacities of Roofs

Roof No.	Construction[a]	*U* Btu per Sq Ft per Hour per Deg F Air Temp. Diff.	Heat Capacity Btu per Sq Ft per Deg F
1	2 in. Concrete, Felt, Pitch, Smooth Black Finish[b]	0.40	6.92
2	No. 1 Insulated[c]	0.17	7.32
3	2 in. Concrete, Felt, Pitch and Slag	0.31	7.41
4	No. 3 Insulated	0.15	7.81
5	2 in. Concrete, Felt, Double Pitch and Slag[d]	0.26	7.92
6	2 in. Concrete, Felt, Pitch and Slag	0.15	7.72
7	6 in. Concrete, Felt, Pitch and Slag	0.28	19.34
8	No. 7 Insulated	0.15	19.74
9	2 in. Reinforced Gypsum, Felt, Pitch and Slag	0.24	4.42
10	No. 9 Insulated	0.13	4.82
11	4 in. Reinforced Gypsum, Felt, Pitch and Slag	0.18	6.89
12	No. 11 Insulated	0.11	7.29
13	4 in. Tile, Felt, Pitch and Slag	0.25	5.80
14	No. 13 Insulated	0.14	6.20
15	2 in. Plank, Felt, Pitch and Slag[e]	0.20	3.22
16	No. 15 Insulated	0.12	3.62
17	2 in. Plank, Felt, Double Pitch and Slag	0.18	3.19
18	2 in. Plank, Felt, Pitch Smooth Black Finish Insulated	0.11	2.93

[a] For more complete description see earlier laboratory report[f].
[b] Water proofing on all roofs consists of 4 ply felt set in pitch except plank roofs which consists of 5 ply.
[c] Insulated roofs had 1 in. structural insulation board under water proofing.
[d] Double pitch and slag roofs had 1st layer of slag filled with pitch and then 2nd layer of slag.
[e] 1⅝ in. matched yellow pine plank.
[f] Loc. Cit. See Note 4.

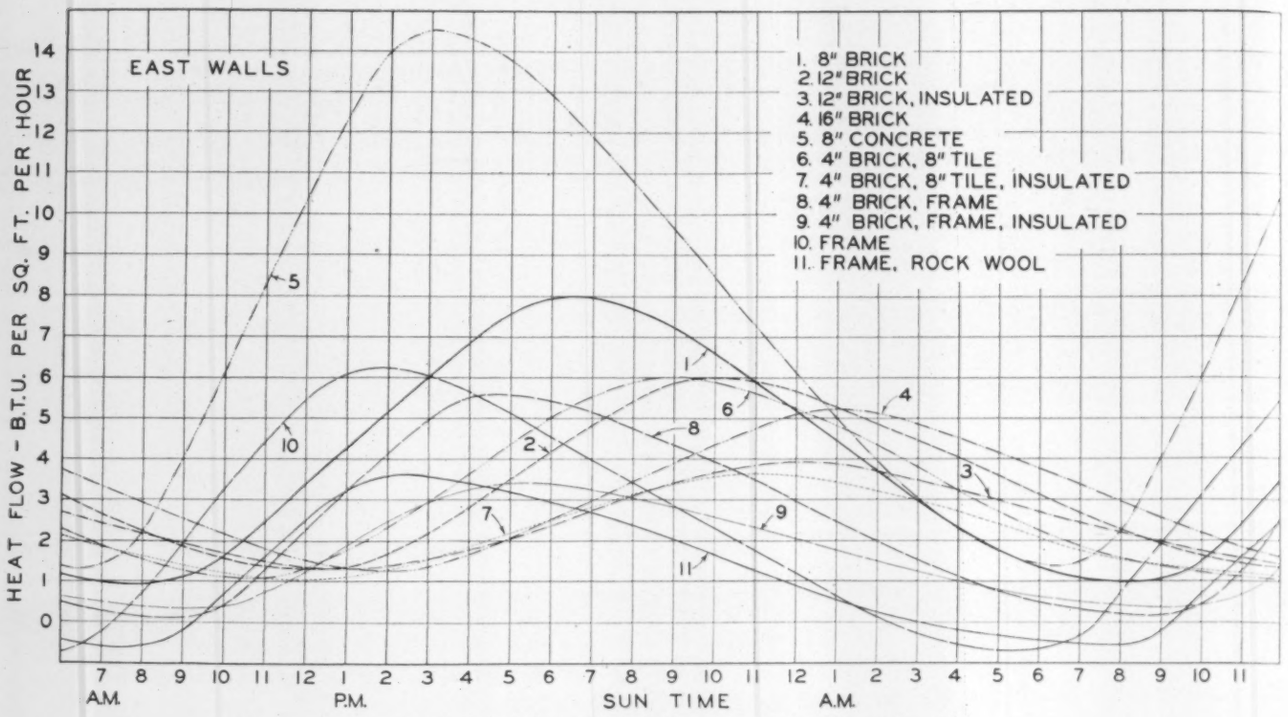

Fig. 2—Heat flow-time relationship for eastern exposed walls

sistance to heat flow and calculated heat capacity for all walls and roofs studied. Figs. 1 to 6 give heat flow —time relationship curves for each of the side walls studied for four orientations and for each of the horizontal roof panels, all for design weather conditions of temperature and solar radiation on August 1; that is, for an August 1 day when the outside temperature reaches a high of 95 F dry-bulb and the solar radiation is of design intensity.

Design Air Temperature and Solar Radiation

The design outside dry-bulb temperatures to be applied to the estimated cooling load in summer air conditioning have been arrived at for different metropolitan districts by committees of the Society and published in THE GUIDE 1942. These values are the maximum temperatures for days occurring with sufficient frequency to be used for design purposes. In this study as in others recently made, it was desirable not only to establish the maximum temperature but also the typical time-temperature curve for the 24-hour period. The result of an analysis of the weather bureau re-

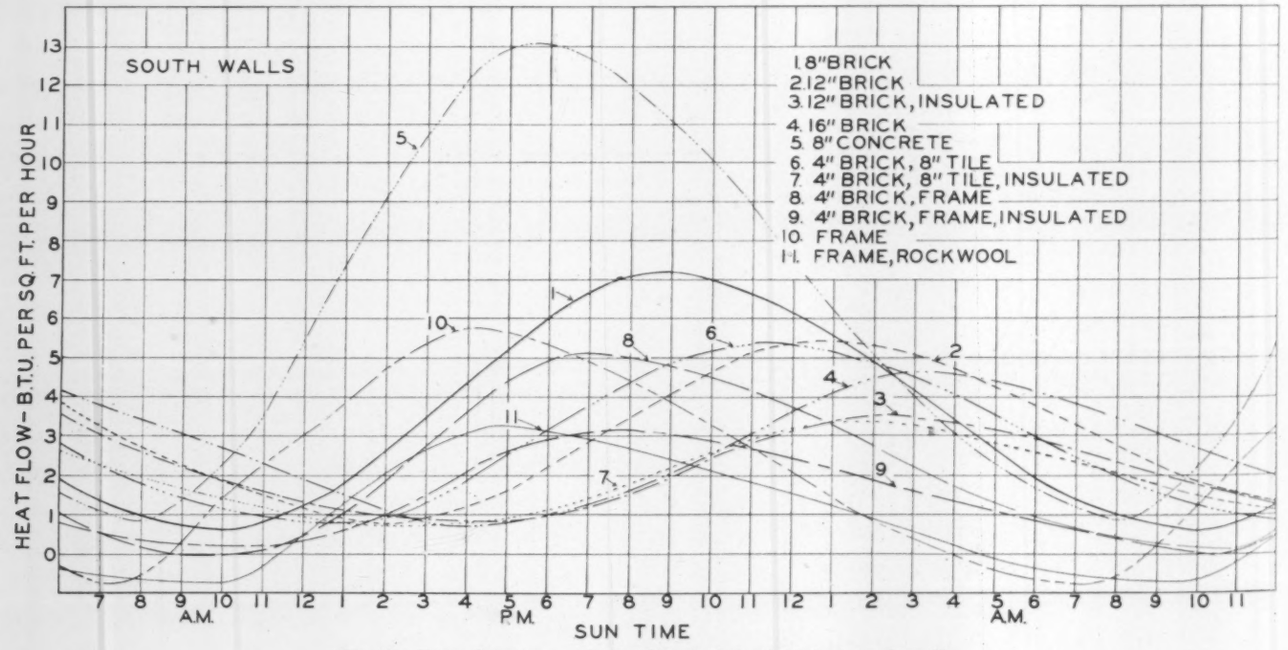

Fig. 3—Heat flow-time relationship for southern exposed walls

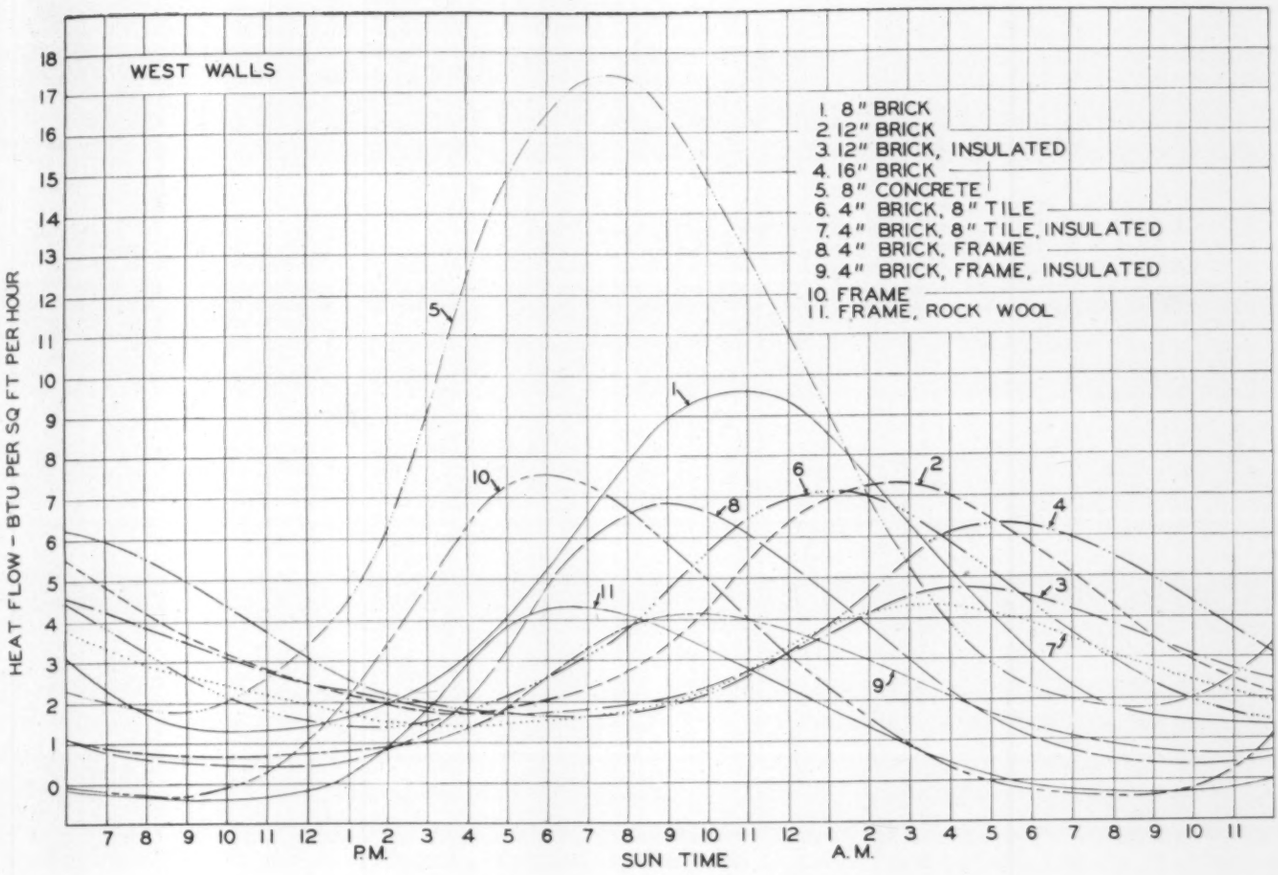

Fig. 4—Heat flow-time relationship for western exposed walls

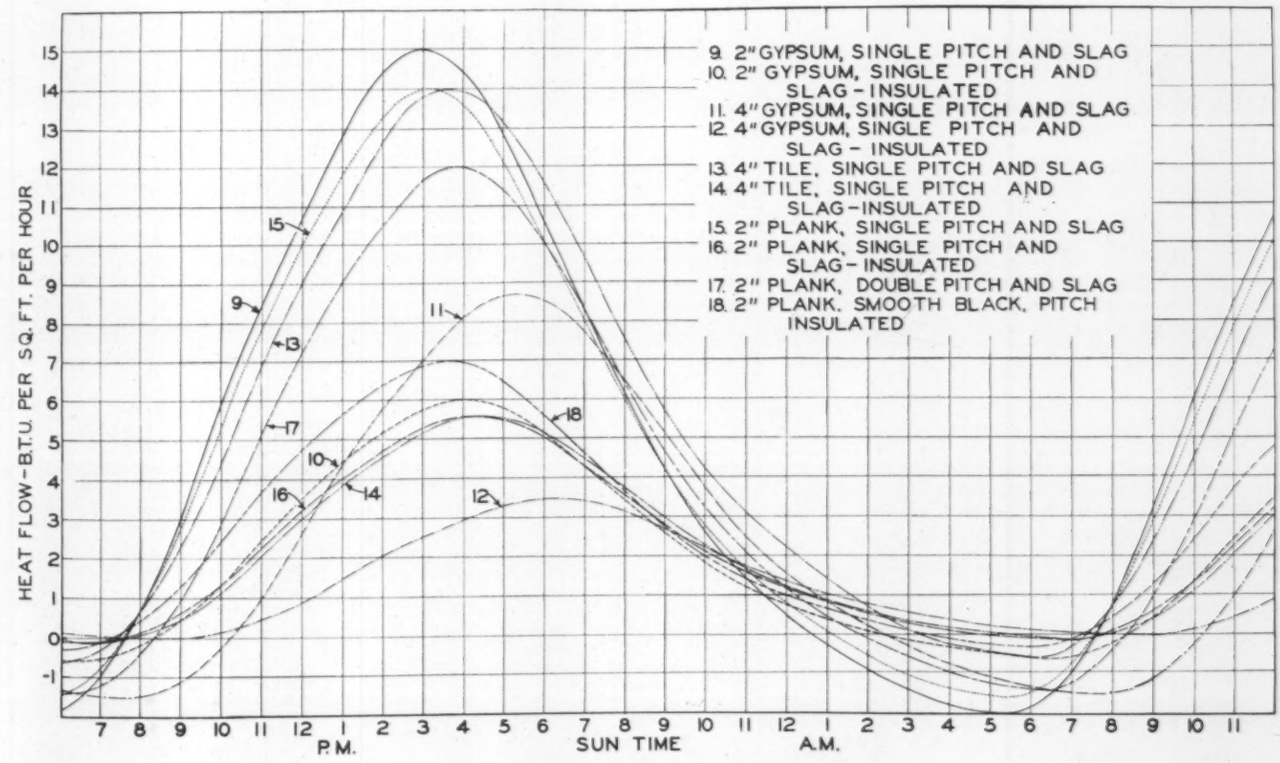
9. 2" GYPSUM, SINGLE PITCH AND SLAG
10. 2" GYPSUM, SINGLE PITCH AND SLAG - INSULATED
11. 4" GYPSUM, SINGLE PITCH AND SLAG
12. 4" GYPSUM, SINGLE PITCH AND SLAG - INSULATED
13. 4" TILE, SINGLE PITCH AND SLAG
14. 4" TILE, SINGLE PITCH AND SLAG - INSULATED
15. 2" PLANK, SINGLE PITCH AND SLAG
16. 2" PLANK, SINGLE PITCH AND SLAG - INSULATED
17. 2" PLANK, DOUBLE PITCH AND SLAG
18. 2" PLANK, SMOOTH BLACK, PITCH INSULATED
HEAT FLOW - B.T.U. PER SQ. FT. PER HOUR
P.M.
SUN TIME
A.M.

Fig. 5—Heat flow-time relationship for horizontal roofs

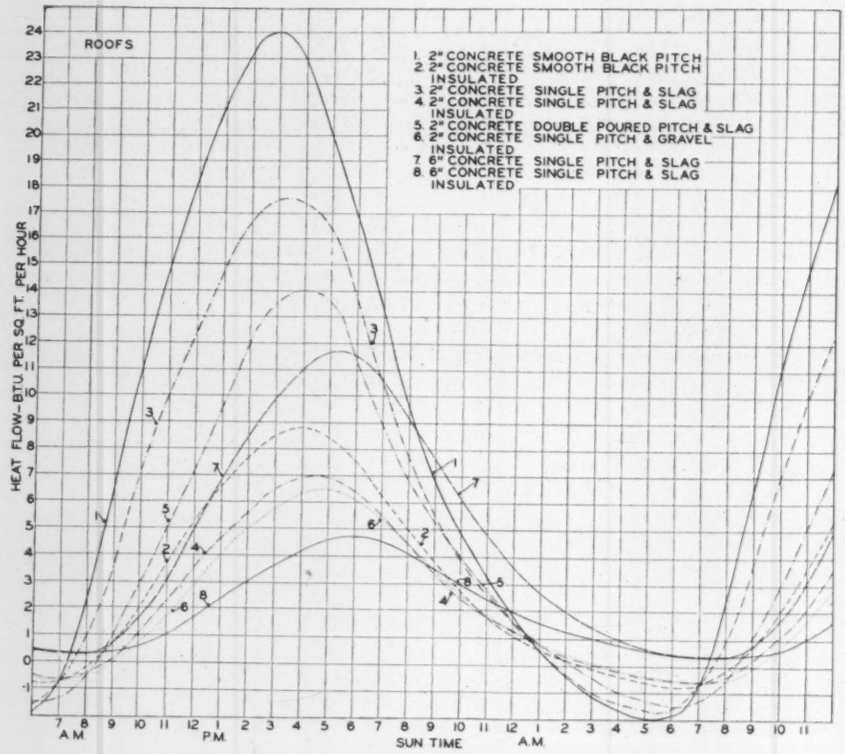
ROOFS
1. 2" CONCRETE SMOOTH BLACK PITCH
2. 2" CONCRETE SMOOTH BLACK PITCH INSULATED
3. 2" CONCRETE SINGLE PITCH & SLAG
4. 2" CONCRETE SINGLE PITCH & SLAG INSULATED
5. 2" CONCRETE DOUBLE POURED PITCH & SLAG
6. 2" CONCRETE SINGLE PITCH & GRAVEL INSULATED
7. 6" CONCRETE SINGLE PITCH & SLAG
8. 6" CONCRETE SINGLE PITCH & SLAG INSULATED
HEAT FLOW-BTU. PER SQ. FT. PER HOUR
SUN TIME
A.M.
P.M.
A.M.

Fig. 6—Heat flow-time relationship for horizontal roofs

ported hourly temperatures for a number of days when the maximum reached 95 F established such a curve given in an earlier Laboratory report.[7]

The Laboratory has found that it is desirable to arrive at design solar radiation curves for different vertical walls facing east, south, and west and for horizontal surfaces. Based upon pyrheliometer observations at the Laboratory and additional observations made over a period of years by the Pittsburgh Station of the U. S. Weather Bureau, solar intensities which might be expected to occur on at least a few days of each summer were arrived at. This includes not only the direct solar radiation intensity received in straight lines from the sun but also scattered or sky radiation. These design solar radiation curves are given in Fig. 7 for August 1, which is assumed to be the time during the summer when the average combined cooling load is maximum. A comparison of the August 1 curves with those for other times of the summer are given in an earlier Laboratory report.[8] For comparison between the design solar intensity for August 1 and the actual solar radiation observed on certain days for which data are included in this report, the curves for a horizontal surface are given in Fig. 8.

Few days occur when both air temperature and radiation reach design values throughout the day. In fact, the experience of the Laboratory during the past 2 years as gained in the preparation of this report indicates that possibly the acceptance of the simultaneous occurrence of both design temperature and design radiation gives too high a cooling requirement. Table 3 gives the maximum outside temperature and the estimated percentage of solar radiation observed on certain days for which data are included in this report. It will readily be seen that the coincidental occurrence of design conditions for both temperature and radiation when based solely upon chance will rarely occur, and further there is some indication and some reason to believe that the lack of concurrence is more than a matter of pure chance for it is possible that extremely warm days are generally associated with the occurrence of cumulus clouds during a part of the day. Haze and clouds observed in Pittsburgh on hot days during this study will probably occur in most industrial metropolitan areas and reduce the solar radiation intensity. There will be exceptions, however, where haze and clouds are less prevalent. This matter should be further studied with the possible reduction of the design heat gain curves here reported, as well as those for localities with other climates and latitudes.

In arriving at the design heat flow curves, Figs. 1 to 6, inclusive, curves for several days when both the outside temperature and solar radiation

Table 3—Weather and Heat Gain Data During a Hot Wave

Date	Maximum Temp.	Per Cent[a] Solar Radiation	Weather	Uninsulated East Wall, 12 in. Brick[b]		Insulated South Wall, 12 in. Brick[c]		West Wall, Frame[d]		West Wall, Frame, Rock Wool[e]	
				Max. Heat Flow Btu/Sq Ft per Hour	Total Heat Gain Btu/Sq Ft per Day	Max. Heat Flow Btu/Sq Ft per Hour	Total Heat Gain Btu/Sq Ft per Day	Max. Heat Flow Btu/Sq Ft per Hour	Total Heat Gain Btu/Sq Ft per Day	Max. Heat Flow Btu/Sq Ft per Hour	Total Heat Gain Btu/Sq Ft per Day
7-23-41	88.5	75	Clear	3.0	32.2	1.0	13.1	4.4	18.2	2.5	13.8
7-24-41	91.0	50	Clear	3.8	40.9	2.0	18.9	5.9	39.4	4.3	31.2
7-25-41	95.0	51	Clear	3.9	48.4	1.9	27.2	5.8	44.0	4.4	34.6
7-26-41	97.0	50	Clear	3.9	66.4	1.8	33.8	4.8	38.4	3.4	32.4
7-27-41	100.2	52	Clear	4.5	64.2	2.2	38.2	4.6	39.4	2.4	28.0
7-28-41	96.0	60	Clear to Cloudy	4.4	82.0	1.9	39.8	5.0	48.4	3.6	36.4
7-29-41	92.2	40	Clear to Rain	4.9	89.8	2.3	43.0	2.9	27.8	2.0	24.4
7-30-41	94.0	86	Clear to Cloudy	5.1	79.0	1.8	30.2	5.4	31.6	3.8	23.8
7-31-41	87.0	40	Cloudy to Rain	No Heat Flows observed							

[a] Per cent of the integrated total for the day.
[b], [c], [d], [e] Walls No. 2, 3, 10 and 11, Table 1.

[7] Heat Gain Through Glass Blocks by Solar Radiation and Transmittance, by F. C. Houghten, David Shore, H. T. Olson and Burt Gunst. (ASHVE Transactions, Vol. 46, 1940.)
[8] Loc. Cit. See Note 7.

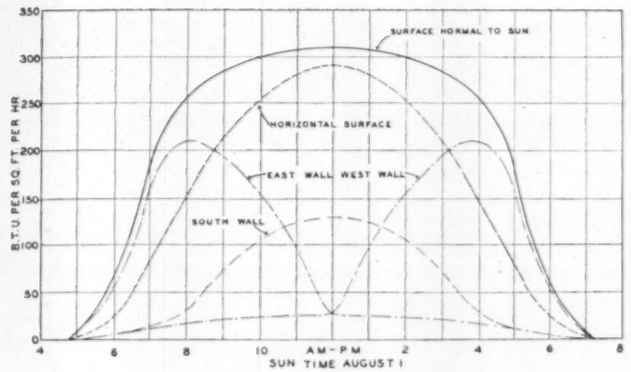

Fig. 7—Design solar radiation on different surfaces

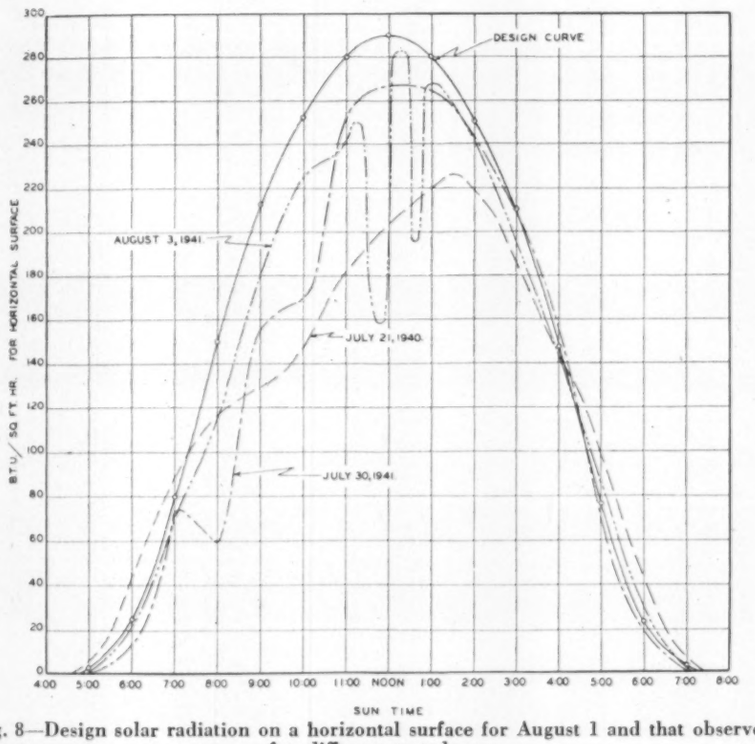

Fig. 8—Design solar radiation on a horizontal surface for August 1 and that observed for different test days

were near design were studied and adjusted by extrapolation. For those walls for which data were obtained for only one orientation the curves were drawn from the relationships found from the few walls studied with more than one orientation.

Test Operation

Each of the 11 side walls and 9 roof panels were equipped with a 2-ft square Nicholls' heat flow meter on the center of the inside surface. At frequent intervals throughout the 24-hour day, for extended periods including all types of summer weather, the following observations were made: heat flows; the outside air temperature 6 in. from each wall and 6 in. above each roof, shielded so as to minimize the effect of solar radiation; the outside surface temperatures; the inside surface temperatures; the air temperature at the control point in the room; and a number of temperatures within the individual walls and roofs. A shielded aspirating psychrometer was used to observe the outside air wet- and dry-bulb temperatures unaffected by the building. Fine wire copper-constantan thermocouples and a precision potentiometer were used for observing all other temperatures. A recording potentiometer provided a record of two, and in some cases three, pyrheliometers, one having its sensitive plane horizontal and the others having this plane vertical and facing either east, south or west. The time-solar radiation intensity curves for the other walls were then determined trigonometrically, a practice which earlier Laboratory work has proved satisfactory.

Heat Gain Relationships for Different Orientations and Types of Construction

Since a number of the types of construction studied had only one orientation, as indicated in Table 1, and, further, since a number of these types of construction, particularly those containing insulation, were only studied on a few satisfactory days and then late in the season, it was necessary to rely upon relationships found for certain walls tested with different orientations and on data collected on several good days to arrive at the relationships on which the entire series of curves in Figs. 1 to 6 are based.

The 12-in. brick and the brick and tile walls were the only walls studied with four orientations; the brick and frame wall was studied with east, south and west exposures only. From the results obtained from these walls, it was found that with minor variations the heat flows through the east, south and north walls were 83, 75, and 46 per cent, respectively, of that for the west wall.

The time relationship between the minimum and maximum heat flows through the several walls with the four orientations was fixed by averaging the results for certain days for the few walls studied with all four orientations and applying this relationship to all the walls. This relationship applies satisfactorily for walls which do not differ too much from those on which it was based. It would not apply to extreme cases such as sheet metal walls.

Hot Waves

Both during 1940 and 1941 the period of test observations for most of the walls included several days of a so-called hot spell. Table 3 shows that between July 23 and July 31, 1941, the maximum temperature ranged from 88.5 F to a

maximum of 100.2 F and back down to 87 F. It is also interesting to note that this period included considerable variation in maximum air temperature, sun radiation, and other weather conditions. It should be of some interest in the design and operation of cooling systems to record the data in Table 3 during this hot spell.

Discussion of Results

This report offers, for design purposes, curves giving the 24-hour heat gain rates for 11 walls and for 18 roofs having wide variation in resistance to heat flow and heat capacity. As the character of the curves in Figs. 1 to 6 themselves indicate, the data in this form, rather than in the form of simple coefficients, must be used if accurate estimates of cooling requirements are desired.

The data presented in this paper are important as an initial contribution toward the accurate determination of the cooling load, and provide the design engineer with needed information on the performance of a typical series of walls and roofs.

Further study of the data is necessary to determine how the observed heat flows compare with the theory relating heat flow to the orientation, heat capacity, transmittance coefficient, and absorptivity of solar radiation by the outside surface of the structure. There is also a need for determination of the effect of re-radiation from adjacent building structures. While it is hardly feasible to establish curves for all types of walls and roofs encountered, it may be possible to include in one chart for each orientation curves for a sufficient number of types of construction, including a wide range in the resistance to heat flow and heat capacity, to permit interpolation for other similar constructions. Data are also desirable for other orientations such as northeast, southeast, northwest and southwest exposures and for other roof slopes. This study suggests the need for additional work to help establish the maximum expected rate of heat flow, particularly with reference to the probable coincidental occurrence of both design solar radiation and design outside temperature.

DISCUSSION

W. F. Fair, Jr., Pittsburgh, Pa. (Written): First I should like to present six comments concerning this paper:

1. Roof No. 6, although being described in Table 2 as being similar to roof No. 3 has tabulated characteristics of roof No. 4 (which is room No. 3 insulated); in Fig. 6, Curve 6 is described as an insulated roof, gravel surfaced.

2. Roofs Nos. 3 *vs.* 1, and 4 *vs.* 2, and 16 *vs.* 18 show the beneficial effect of addition of slag.

3. Roofs Nos. 5 *vs.* 3 (and in turn *vs.* 1), and Nos. 15 *vs.* 17 illustrate the improvement due to double pitch and slag.

4. Roofs Nos. 6 *vs.* 4 indicates almost negligible superiority of gravel over slag (provided amounts used and thicknesses are the same—U and Heat Cap. are equivalent).

5. Roofs Nos. 7, 5 and 3 indicate that a second pitch application may be approximately equivalent to 2 in. of concrete in the base.

6. If roofs Nos. 7 and 11 were given a double pitch application their curves might drop down to the peaks for insulated materials; and if Nos. 8 and 12 were given double pitch coatings their curves might be expected to be even flatter and lower.

These results emphasize the value of applying double pitch and slag coatings to roofs. It seems probable that a triple application, if practicable, would give even better results, or permit the use of smaller thickness of base material for approximately the same heat flow characteristics; an additional application to an easier means to effect improved heat flow characteristics (together with simultaneous increase in resistance to weathering) than by interior constructional methods.

Dr. Houghten: To reply adequately to all of the questions involved would take a little time, but I believe they can be generalized.

Mr. Fair brought out a typographical error in his first comment and the particular roof mentioned should have been indicated as gravel covered with insulation. One of the most surprising results from the roof study was the apparent magnitude of the resistance to heat flow added by the waterproofing membrane of a number of the roofs. It is true that the waterproofing member on the 2-in. concrete roof has about the same effect as the 2-in. concrete itself, which has been quite surprising to various individuals, including the Guide Publication Committee.

One way of accounting for all the previously published data on roofs showing a much smaller effect of the waterproofing has been due to the fact that the waterproofing considered was very thin. The waterproofing members used in these tests were rather thick and built up to about a quarter of an inch to three-eighths, while some of the earlier dealt with only one or two thicknesses of felt and pitch. Apparently the gravel had just about the same effect as slag of the same thickness. Contrary to the usual conception the slag had considerable effect and that is easily accounted for by not so much the resistance to heat flow through the slag as the fact that the slag offers considerable heat capacity.

John Everetts, Jr., Pittsburgh, Pa.: By reference to Table 3, giving the weather and heat data during the hot wave, there are some very interesting details reported. It seems that the design curve data for heat gain through walls under various conditions as compared to the data in Table 3 are a little high. Apparently this is due to the conservative feeling on the part of the Laboratory in that they have considered maximum solar radiation and maximum temperature to be coincidental.

From the work of the Research Technical Advisory Committee on Weather Design Conditions we do not feel that a coincident condition of maximum sun effect and temperature is possible, inasmuch as the maximum solar radiation would be impeded by haze or fog or dust particles which would tend to settle during maximum temperature conditions due to the lack of circulation of atmospheric air. Therefore, we feel that the design values as obtained from the curves in this paper will give greater results than required.

By taking the design conditions reported we find that for the east wall as given in the table, which shows a maximum heat transfer of 5 Btu per square foot per hour, the 1940 and 1941 editions of The Guide would show equivalent heat transfer values by calculation of 16.9 Btu or about three times as much as the value given in Table 3, and also from the curve which indicates 6 Btu.

On the west wall we show a comparison of the Guide recommendation value of 9 as against the curve data of 7.5. On the south wall a Guide value of 4.5 against the curve value of 3.5, and similar wall comparisons could be made. This means that if we take the example as given in the Chapter on Cooling Load of The Guide we find that in the 1940 Guide the particular little store application problem which has been used in The Guide from 1932-1940, without much change in physical dimensions, started out with a load of 9.6 tons. That same store now only requires 7.3 tons, or 7.5-ton unit, or a 25 per cent reduction to the owner in the selection of equipment.

In view of the analysis which the ASHVE Research Laboratory has done in determining heat flow curves through building walls, which has reduced the values in our calculated measurement, or the application of comfort air conditioning, it has definitely brought out improvement in a design application and engineering of such installations. We would like to see additional information of

other types of walls and roofs investigated at the Society's Laboratory to complete this program as soon as possible.

C. M. Ashley, Syracuse, N. Y.: I would like to suggest that this paper be considered as a part of a continuation program, or in other words, somewhat in the nature of a progress report. The Laboratory work is still being carried on and quite a lot of work remains to be done in order to finish the job and provide all the data that are needed by the air conditioning industry. The Research Technical Advisory Committee on Cooling Load and Summer Air Conditioning felt that these data were of such value that it fully justified the publication of the report at the present time rather than hold it until such time as we had obtained complete information.

It is hoped that over the period of the next few months further work can be done on this subject which is of an analytical character. First it is hoped that the data which have already been obtained can be studied from a mathematical point of view, so that a formula can be developed to predict the performance of a variety of other types of walls and roofs.

Further than that it is hoped that we can obtain additional data, such as the actual heat transmission through the wall, the amount of absorption on the surface of a wall and the collection of weather data to determine whether the solar radiation assumed and the wet and dry-bulb temperature conditions assumed for the design curve are actually coexistent or not.

Dr. Paschkis: I believe that Dr. Houghten and his co-workers did a marvelous piece of work as reported in this paper, but there are two things that come to my mind. One is that the interference of the outside wind is not mentioned and I believe the experiments which were presented in my paper show that this factor has a great influence on the wall. Consequently, I feel that it is important to carry on the experiment in such a way that a mathematical formula can be devised to select the heat flow through various types of walls.

Guarded Hot Box Test of Single- and Double-Glazed Windows

By Merle M. McClure,* Lafayette, Ind.

Three important functions are served by the use of double-glazed windows or of single-glazed windows protected by storm sash:

1. A reduction is effected in the amount of heat lost through windows, which in the case of the average house equipped with single-glazing is approximately 30 per cent of the total heat demand.
2. Condensation on windows, which causes great inconvenience and is detrimental to the inside finish, is prevented.
3. Comfort conditions are improved by higher window-surface temperatures, reducing the mean radiant temperature loss.

It is readily apparent that window design and construction are important from the viewpoint of fuel-saving and of healthful and comfortable living.

Problem in Consideration

In the experiments described in this article, the problem was to compare the over-all heat transmission of a single-glazed window, of a double-glazed window with various spaces between the panes, and of a single-glazed window protected by storm sash. Difficulties in maintenance were considered in appraising the results. A unique feature of a number of these tests was that an air velocity of 15 mph was maintained over the cold side of the test specimen.

Method of Test

In executing this series of tests, the guarded hot box method, standard for this type of investigation, was employed. The apparatus used is illustrated diagrammatically in Fig. 1, which shows that the test specimen, in this case the window, was installed between the cold box and guarded hot box. The refrigerator unit, with the evaporator coil in the cold box, maintained the low temperature on one side of the window. The blower with duct, plenum chamber, and baffle was used to produce the desired air movement parallel to the cold-side surface of the window. The window was sealed between the two portions of the apparatus so that heat transfer from the warm side to the cold side was by conduction. The hot box was sealed at the surface of the window to prevent convection from or to the guard space. The temperature in the guard space was maintained automatically to be equal to that in the hot box. With no temperature differential between the two boxes, there was no heat transmission by conduction from one box to the other. The electric heating elements

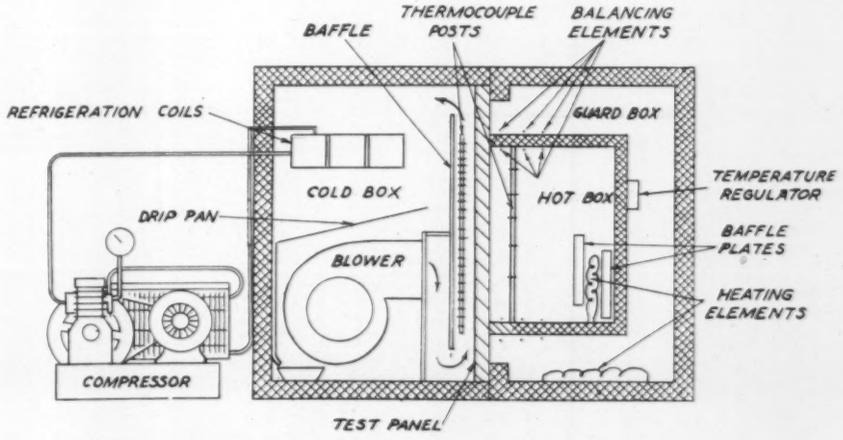

Fig. 1—Vertical cross-section of heat transfer test equipment

*School of Mechanical Engineering, Purdue University.

Fig. 2—Test window, with 2 in. space between glass, installed in hot box

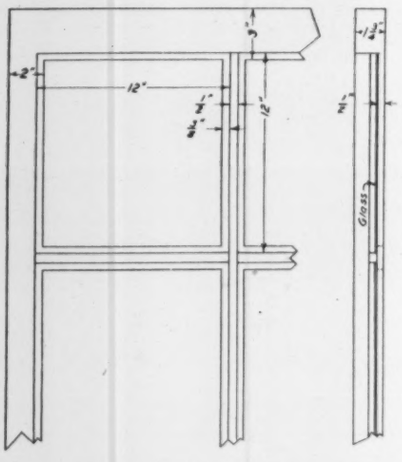

Fig. 3—Sketch showing corner section of test window

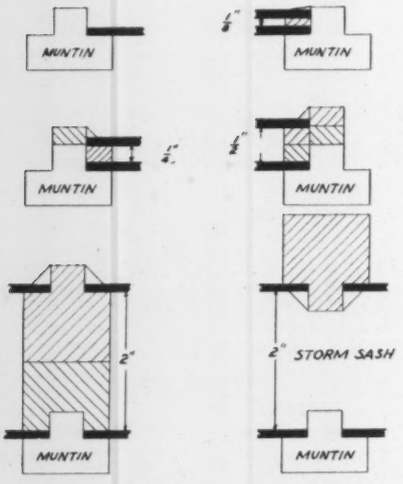

Fig. 4—Sketch showing method of forming space between panes in double glazing

were shielded with magnesia slabs to prevent direct radiant transmission. The heat to maintain predetermined temperature in the hot box was introduced as electrical energy, the quantity being determined by a wattmeter. As no temperature differential existed except that from the hot box to the window, this quantity of heat supplied to the hot-box heating element was lost through the window. Thermocouples were used to determine the temperatures in the hot-box air, on the warm and cold surfaces of the window, and in the cold-box air. Since the temperature gradient from warm air to cold air, the quantity of heat supplied to the hot box, and the area through which the heat passed were known, the thermal coefficients of the window were determined.

Fig. 2 shows the apparatus ready to be closed with the window secured to the guarded hot-box portion.

Test Window

A special, heavy framed, 16-pane window with 12-in. by 12-in. glass was constructed for use in this series of tests. The muntins were also made of heavy stock and were left flat on the face to facilitate their extension in double glazing. Details of the construction are shown in Fig. 3.

After the single glazing tests were made, the window was double glazed, first with ⅛ in. air space between the glass, second with ¼ in., third with ½ in., fourth with 2 in., and last a storm sash with 2 in. air space. Fig. 4 shows the method of making extensions to the original sash. It will be noted on the figure that there is a slight variation in the muntin projection beyond the glass.

Test Procedure

With the window installed between the cold box and guarded hot box, the refrigerating equipment was started and the hot box and guard box heating circuits were closed. The control instruments were set for the desired temperature and the apparatus was allowed to run until thermal equilibrium was attained. The temperatures and wattages were read for a sufficient period to assure constant condition and from these data the thermal coefficients were computed.

Air movement in the hot box and guard box was by natural convection. In tests with still air conditions this was true in the cold box. With air movement of 15 mph over the cold surface the blower, as shown in Fig. 1, was used. When the blower was started after a still air test, considerable time was required to rebalance the thermal conditions because of the increased heat demand.

Table 1—Heat Transmission Through Wood Sash with Single and Double Glazing

Air velocity, fpm, cold side	90	1320	1320	1320	1320	1320	1320	90
Air velocity, mph, cold side	1.0	15.0	15.0	15.0	15.0	15.0	15.0	1.0
Glazing	Single	Single	Double	Double	Double	Double	Storm	Sash
Air space, inches	—	—	0.125	0.25	0.50	2.0	2.0	2.0
Temperatures, deg F								
Warm side air	76.5	76.2	93.7	93.3	92.1	94.6	94.6	96.2
Warm surface	—	—	76.5	77.7	79.4	79.5	78.1	82.1
Cold surface	—	—	60.5	60.1	59.5	53.8	55.4	62.6
Cold air	37.2	43.6	56.0	55.7	56.7	50.0	51.4	48.4
Temperature Differences, deg F								
Warm air to surface	—	—	17.2	15.6	12.7	15.1	16.5	14.1
Surface to surface	—	—	16.0	17.6	19.9	25.7	22.7	19.5
Surface to cold air	—	—	4.5	4.4	3.3	3.8	4.0	14.2
Cold air to warm air	39.3	32.6	37.7	37.6	35.9	44.6	43.2	47.8
Mean temperature, deg F	56.8	59.9	74.8	74.5	74.2	72.3	73.0	72.3
Btu transmitted per sq ft per hour	28.7	36.1	28.1	25.2	22.0	26.2	27.9	22.8
Conductance (C) Btu per sq ft per hour per degree temperature difference								
Warm side surface conductance, (f_i)	—	—	1.64	1.62	1.74	1.73	1.69	1.62
Cold side surface conductance, (f_o)	—	—	6.25	5.74	6.65	6.88	6.98	1.61
Warm surface to cold surface, (C), (air space)	—	—	1.76	1.43	1.10	1.02	1.18	1.16
Over-all transmission, air to air, (U)	0.73	1.11	0.75	0.67	0.61	0.59	0.65	0.45

Results and Conclusions

The heat savings to be obtained by the use of double glazing with various spaces between the panes and by the use of storm sash are shown graphically in Fig. 5. No important benefit was gained by increasing the space between the panes to more than ½ in. in the double-glazed window. Before the ½ in. space it will be seen that the curve is quite steep while it is very flat beyond this point. The storm sash performance with 2-in. space compared favorably with the double glazing, being equivalent to double glazing with a space of approximately ⅜ in.

Double glazing or single glazing protected by storm sash raises the inside surface temperature of the

Table 2—Recapitulation of Experimental Data on Heat Transmission Through Windows

Authority	*U* Btu/Hr/Sq Ft/Deg Temp. Diff.	Glass Set Up: Glass Thickness	Air Space	Area: Total	Area: Test	Application	Hot Box: Temp	Hot Box: Vel mph	Cold Box: Temp	Cold Box: Vel mph	Mean Temp
K[a]	1.02	2	None	1.2m²	1.1m²	Single glass 1 light	65.7	Two fans run at such a speed as to give a temperature distribution at the wall surface inside the hot box just the same as the surface outside the box	−3.1	Nat. Circ.	31.3
	0.63	2	None	1.2m²	1.1m²	Double glass 1 light	68.0		−0.4	Nat. Circ.	33.8
	0.53	2	1 cm	1.2m²	1.1m²	Double glass 1 light	68.0		−3.5	Nat. Circ.	32.3
	0.49	2	1 cm	1.2m²	1.1m²	As above with 1 m² spacing frame between the light	69.0		−4.7	Nat. Circ.	32.2
	0.51	2	1 cm	1.2m²	1.1m²	As above with four vertical dividing rods	68.9		−4.9	Nat. Circ.	32.0
	0.51	2	1 cm	1.2m²	1.1m²	As above except for horizontal dividing rods	68.4		−5.8	Nat. Circ.	31.3
	0.47	2	10 cm	1.2m²	1.1m²	Double glass 1 light	64.4		1.4	Nat. Circ.	32.9
	0.45	2	10 cm	1.2m²	1.1m²	Double glass with 1 m² spacing frames	68.0		−2.7	Nat. Circ.	32.9
	0.45	2	10 cm	1.2m²	1.1m²	As above with four vertical dividing rods	64.8		−0.8	Nat. Circ.	32.0
	0.45	2	10 cm	1.2m²	1.1m²	As above except for horizontal dividing rods	68.0		1.8	Nat. Circ.	34.9
	0.28	3	5 cm	1.2m²	1.1m²	Triple glass 1 light	68.4		−2.9	Nat. Circ.	32.7
	0.22	4	3.3 cm	1.2m²	1.1m²	Quadruple glass 1 light	67.8		−7.8	Nat. Circ.	30.0
	0.77	1	.....	1.3m²	1.0m²	Single glazed window—wood sash 9 lights; 40 cm x 40 cm each	66.2		−0.9	Nat. Circ.	32.5
	1.26	1	.....	1.3m²	1.0m²	Single glazed window—wood sash 9 lights; 40 cm x 40 cm each	62.4		6.8	5.6 mph	34.6
	0.57	2	2 mm	1.3m²	1.0m²	Double glazed window—130 cm sq wood sash—9 lights; 40 cm x 40 cm each	66.7		−4.7	Nat. Circ.	31.0
	0.83	2	2 mm	1.3m²	1.0m²	Double glazed window—130 cm sq wood sash—9 lights; 40 cm x 40 cm each	67.1		−3.3	5.6 mph	31.9
	0.59	2	2 mm	1.3m²	1.0m²	Double glazed window—130 cm sq iron sash—lights 42 cm x 42 cm each	68.0		−2.7	Nat. Circ.	32.7
	0.47	3	2 mm	1.3m²	1.0m²	Triple glazed window—130 cm sq wood sash—lights 40 cm x 40 cm each	67.5		−3.1	Nat. Circ.	32.2
	0.63	3	2 mm	1.3m²	1.0m²	Triple glazed window—130 cm sq wood sash—lights 40 cm x 40 cm each	67.6		−2.9	5.6 mph	32.3
	0.42	2	3.5 cm	1.3m²	1.0m²	Double window—wood sash each window—9 lights 40 cm x 40 cm each	65.8		−0.9	Nat. Circ.	32.5
	0.39	2	10 cm	1.3m²	1.0m²	Double window—wood sash each window—9 lights 40 cm x 40 cm each	67.3		−2.9	Nat. Circ.	32.2
	0.51	2	10 cm	1.3m²	1.0m²	Double window—wood sash each window—9 lights 40 cm x 40 cm each	66.2		−2.7	Nat. Circ.	31.8
S[b]	1.19	1	.....	4 ft 2¾ in. x 7 ft 9¼ in.		Single glazing 20 lights 12″ x 18″—¼″ rough wire-glass solid rolled steel sash	.....	Still Air	.....	7 mph	95.0
	1.06	1	.....	4 ft 2¾ in. x 7 ft 9¼ in.		Same as above except for wood sash	.....	Still Air	.....	7 mph	95.0
	1.10	1	.....	4 ft 2¾ in. x 7 ft 9¼ in.		Same as above except for hollow metal sash	.....	Still Air	.....	7 mph	95.9
	0.85	2	¾ in.	4 ft 2¾ in. x 7 ft 9¼ in.		Double glazing outside—¼″ wire glass inside—Single plain glass—solid steel sash	.....	Still Air	.....	7 mph	95.0
	0.94	2	⅜ in.	4 ft 2¾ in. x 7 ft 9¼ in.		Double glazing outside—⅛″ ribbed glass—inside single plain glass solid steel sash	.....	Still Air	.....	7 mph	95.0
	0.58	2	⅝ in.	4 ft 2¾ in. x 7 ft 9¼ in.		Double glazing outside—¼″ wire glass—inside—double plated glass wood sash	.....	Still Air	.....	7 mph	95.0
	0.63	2	¾ in.	4 ft 2¾ in. x 7 ft 9¼ in.		Double glazed 12 lights 14½″ x 21″—outside ¼″ wire glass—inside—single plate glass—hollow metal	.....	Still Air	.....	7 mph	95.0
PTL[c]	1.10	1	.....	7 ft 4⅜ in. sq		Single glazing—36 lights steel sash	.....	2.18 mph	.....	0.66 mph	35
	0.99	1	.....	7 ft 4⅜ in. sq		Same as above except for 9 lights	.....	2.18 mph	.....	0.66 mph	35
	0.71	2	¼ in.	7 ft 4⅜ in. sq		Double glazing—36 lights steel sash	.....	2.18 mph	.....	0.66 mph	35
	0.60	2	¼ in.	7 ft 4⅜ in. sq		Same as above except for 9 lights	.....	2.18 mph	.....	0.66 mph	35
	0.65	2	⅛ in.	7 ft 4⅜ in. sq		Same as above except for 9 lights	.....	2.18 mph	.....	0.66 mph	35
	0.56	2	⅜ in.	7 ft 4⅜ in. sq		Same as above except for 9 lights	.....	2.18 mph	.....	0.66 mph	35
	0.55	2	½ in.	7 ft 4⅜ in. sq		Same as above except for 9 lights	.....	2.18 mph	.....	0.66 mph	35
	0.54	2	⅝ in.	7 ft 4⅜ in. sq		Same as above except for 9 lights	.....	2.18 mph	.....	0.66 mph	35
Allen[d]	0.64	1	.....	16 sq ft		Single glass	.....	.....	.....	.....	.....
Shaw[e] Dec. 1920	0.6—0.7	2	½ in. ¾ in.	.....	.....	Double glass wood sash	.....	.....	.....	.....	.....
H&H[f]	1.10	1	.....	25 sq ft		⅛ in. single glass	.....	.....	.....	.....	40
MM[g]	0.73	1	.....	25 sq ft	9 sq ft	Single glass 12 light	76.5	Nat. Circ.	39.3	1 mph	56.8
	1.11	2	.....	25 sq ft	9 sq ft	Double glass 12 light	76.2	Nat. Circ.	32.6	15 mph	59.9
	0.75	2	⅛ in.	25 sq ft	9 sq ft	Double glass 12 light	93.7	Nat. Circ.	37.7	15 mph	74.8
	0.67	2	¼ in.	25 sq ft	9 sq ft	Double glass 12 light	93.3	Nat. Circ.	37.6	15 mph	74.5
	0.61	2	½ in.	25 sq ft	9 sq ft	Double glass 12 light	92.1	Nat. Circ.	35.9	15 mph	74.2
	0.59	2	2 in.	25 sq ft	9 sq ft	Double glass 12 light	94.6	Nat. Circ.	44.6	15 mph	72.3
	0.65	2	2 in.	25 sq ft	9 sq ft	Storm sash 12 lights	94.6	Nat. Circ.	43.2	15 mph	73.0
	0.45	2	2 in.	25 sq ft	9 sq ft	Storm sash 12 lights	96.2	Nat. Circ.	47.8	1 mph	72.3

[a] K—Kreuger and Erickson 1922-1924.
[b] S—Sheldon 1916.
[c] PTL—Pittsburgh Testing Laboratory 1938.
[d] Allen 1916.
[e] Shaw 1920.
[f] H & H—Hammond and Holmberg 1917.
[g] MM—Miller and McClure 1939.

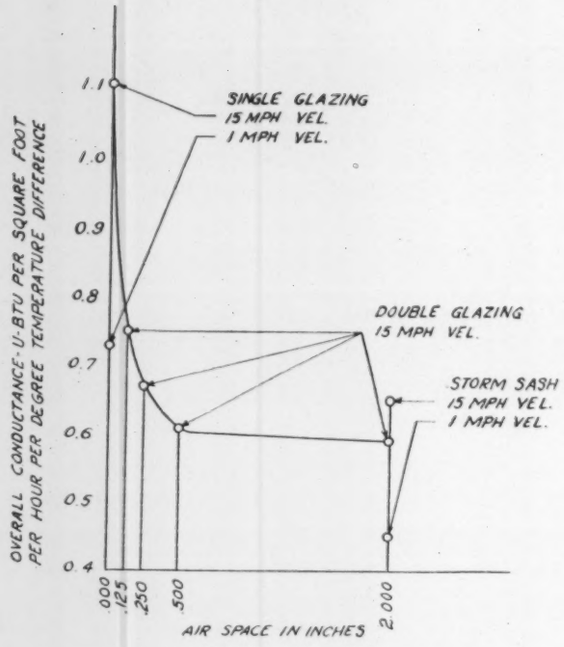

Fig. 5—Graph showing effect of double glazing and air movement on over-all conductance of wood sash window

window. This achieves two objectives:

1. The surface temperature is maintained above the dew-point of the inside air, thus eliminating the nuisance of frost on the glass or condensate, which causes inconvenience and detriment to the inside finish.

2. The higher surface temperature improves the comfort conditions, in that radiant loss from the body to the window is greatly reduced.

In the consideration of double glazing, other factors besides heat transfer enter into the problem. With the two glasses sealed in frames there are two surfaces that are not accessible for cleaning. If the inside is not sealed vapor tight, the trouble of condensation arises, vapor entering on the warm side and condensing on the cold glass. To remove this it would be necessary to vent the space to the cold side.

With storm sash there are usually sufficient cracks around the window frame to allow vapor to escape before it condenses on the cold surface. If there is a collection of condensation between the two, it is easily removed by opening the storm sash to the cold side and allowing it to re-evaporate.

To install double-glazed windows would require special construction that would increase the cost over standard window and storm sash. With storm sash, they are readily removed for cleaning. For the average home the storm sash would be preferable.

It will be noted from Table 1 that the value of 1.11 for single glazing compares favorably with the value of 1.13 reported in THE ASHVE GUIDE for single glazing with 15 mph wind velocity. It will also be noted that the film conductances both for still air and for 15 mph agree quite satisfactorily with generally accepted values. Agreement of these values contributes to the reliability of the over-all coefficients obtained in this series of tests.

This series of tests has served to extend the investigation of heat transmission through double-glazed windows to the range of higher velocities. While the reliability of these tests is well established, other tests should be made covering a wider range in mean temperatures and in temperature differences. The general acceptance of values such as these should be made after the series has been extended. While other series of tests have been made at lower velocities in which the range of mean temperatures has been well covered, it would seem advisable to continue these tests with 15 mph controlled velocity over the cold surface.

Table 2 presents a recapitulation of test results† on transmission through glass for both single and multiple glazing from several authors as prepared by F. C. Houghten, Director of the ASHVE Research Laboratory, with the addition of the results of tests made by W. T. Miller and the author in the Heat Transfer Laboratory at Purdue University, as reported in detail in this article. The footnotes of Table 2 show that this work has been done over a rather long period of time. Other works on this subject have been published[1, 2] previously and will be of interest to readers of this paper.

The Pittsburgh Testing Laboratory tests of a 36 light window are comparable to the tests reported in this article both as to procedure and test specimen. The P.T.L. tests were made over a wide range of mean temperatures for the various air space thickness with comparatively low air velocities. The work of the Purdue Tests features the cold side 15 mph velocity with a varying air space thickness.

†A Review of Glass Transmittance Coefficients, by F. C. Houghten, M. L. Carr and David Shore. (ASHVE JOURNAL SECTION, *Heating, Piping & Air Conditioning*, November 1941, p. 716.)

[1]Heat Transmission Through Various Types of Sash, by Arthur N. Sheldon. (*ASME Transactions*, Vol. 38, 1916, p. 857.)

[2]Heat Transfer Through Single and Double Glazing, by M. L. Carr, R. A. Miller, Leighton Orr and Alan C. Byers. (ASHVE TRANSACTIONS, Vol. 44, 1938, p. 471.)

THE FIELD OF ENGINEERING

A new vocational guidance booklet on engineering, intended for the use of high school students and their advisers, has just been published by the Engineers' Council for Professional Development, 29 W. 39th St., New York, N. Y. The booklet entitled *Engineering as a Career*, is intended to help students decide whether they are fitted to be engineers, but the general picture of the engineering field is limited to broad generalizations, is incomplete because of the omission of any listing of many recognized engineering organizations and would lead the reader to believe that only 6 national engineering societies are functioning.

The booklet is divided into two sections, The Scope of Engineering and Principal Branches of Engineering, and also contains a list of vocation-guidance books and pamphlets, primarily concerned with engineering and related vocations. Single copies of the booklet may be obtained for ten cents each.

Determining Sound Attenuation in Air Conditioning Systems

By D. A. Wilbur* and R. F. Simons**, Troy, N. Y.

This paper is the result of research sponsored by the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS in cooperation with Rensselaer Polytechnic Institute.

SUMMARY—The requirements are stated for a basic method of determining attenuation. A detailed description of a method satisfying these conditions is given, with experimental evidence to show the necessity of the requirements and the degree to which they are met. The results of the application of this method to straight unlined ducts show that attenuation in this case is less than 0.2 db per foot except in the regions of panel resonance of the duct walls, and except for high frequencies in small ducts

Introduction

THIS PAPER reports part of a three-point program initiated by the ASHVE Research Technical Advisory Committee on Sound Control[1]. The basic object is to make possible calculation in advance of installation of the noise levels which will be generated by heating, ventilating and air conditioning equipment. In order to do this it is necessary to know:

1. The amount of noise energy which will be generated by such equipment.
2. Losses which will normally occur as the sound passes through the ventilating duct system.
3. The effect of the conditioned space itself and its noise level upon the residual sound energy from the system.

This report deals with item 2. It describes the development of an experimental technique, and the results of experiments on the first aspect of the problem, the energy losses in straight, unlined ducts of various sizes. Future investigation will deal with sound energy losses in elbows, dividers, changes of area, etc. It is hoped that when the work is completed it will be possible to compute sound attenuation with the same confidence as air flow resistance.

Development of Measurement Method

A method which may be relied upon to give complete information must meet the following requirements: (*a*) provision must be made for measuring the attenuation at different frequencies, since in general it varies with frequency; (*b*) the effects of reflection at the ends of the test duct must be minimized in order to separate the attenuation caused by the duct itself from that caused by junctions with other parts of the system; (*c*) provision must be made for exploring the sound level throughout the length of the test duct, for the purpose of determining whether or not the attenuation is the same at all points along the duct, and in order to find the magnitude and phase of any residual standing wave pattern.

In developing a method to meet these conditions several sequences of measurements were made in accordance with the following schedule:

1. Measurements on a small duct (6 in. x 6 in. x 20 ft, 26 gage) terminated in an absorbing conduit.
   - *a*. Single frequency measurements.
   - *b*. Measurements with narrow bands of frequencies.
2. Measurements on a large duct (12 in. x 36 in. x 20 ft, 22 gage).
   - *a*. Duct terminated in an infinite baffle.
   - *b*. Duct terminated in a lumped impedance network providing high absorption at a particular frequency.

Apparatus

The experimental arrangement for part 1-*a* is shown in Fig. 1. The sound source consisted of a 4-in. cone-type electrodynamic loud speaker *A* driven by a beat frequency oscillator *C*, whose frequency range is 0 to 20,000 cycles per second. Thus condition (*a*) was satisfied. The speaker was mounted in the absorbing baffle box *B* in order to materially decrease the acoustic coupling between the speaker and the air in the laboratory. The reason for thus enclosing the speaker was to prevent variations in the standing wave pattern set up in the room from causing the output of the speaker to fluctuate when it was driven at a single frequency.

Condition (*b*) was met by terminating the duct *D* in the absorbing conduit *E*. This conduit was a wooden tube 20 ft long having the same transverse dimensions as the test duct, and was lined with rock wool whose thickness increased with the distance away from the test duct, as shown in the figure.

The flexibility of the sound level measuring probe system demanded by condition (*c*) was the most stringent requirement to meet. The system shown in the figure was finally considered to be the most satisfactory. The probe element consisted of a diaphragm actuated Astatic crystal microphone element *F* (diameter 2 in., maximum thickness 0.5 in.). This microphone was suspended by small rubber bands from the shielded cable *G* which, together with the turnbuckle *H*, formed an endless belt passing over the pulleys *P*. The microphone was electrically connected to the two conductors of the cable *G* by very fine stranded wire. Thus mechanical vibrations of the cable were quite effectively prevented from reaching the microphone. The longitudinal position of the microphone was determined from the position of the turnbuckle which was read in the linear scale *I*. The end of the cable at the turnbuckle *H* was electrically connected to the

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[1] *Committee Personnel*—J. S. Parkinson, *Chairman;* E. L. Anderson, C. M. Ashley, A. L. Kimball, V. O. Knudsen, R. D. Madison, R. F. Norris, C. H. Randolph, A. E. Stacey, Jr., A. G. Sutcliffe and R. M. Watt, Jr.

Presented at the 48th Annual Meeting of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, Philadelphia, Pa., January, 1942.

input circuit of voltage amplifier *J*, across whose output terminals were connected the copper-oxide voltmeter *V*, and the cathode-ray oscilloscope *O*. Since the microphone element was actuated by the sound pressure, the voltmeter reading at any particular frequency was taken to be proportional to the sound pressure at the point in the duct where the microphone was located. The oscilloscope was used for monitoring purposes: to detect distortion or extraneous sound which would give a spurious reading on the voltmeter. The small size of the probe system minimized the disturbance of the sound field due to diffraction, and the continuous motion of the microphone permitted the determination of relative sound pressure at any point along the duct.

Test Procedure

The first procedure with this experimental arrangement consisted of a determination of the longitudinal pressure distribution in the duct. The following steps were executed: the loud speaker was energized at a single frequency and the level maintained constant. The microphone was then moved down the duct, with frequent pauses, at which points the position of the turnbuckle and the voltmeter reading were noted. Care was taken to make readings at the points of maximum and minimum sound pressure. This procedure was repeated at many different frequencies. The values of relative sound pressure thus obtained were plotted against the longitudinal position of the microphone as shown in the representative curves of Fig. 2. It should be noted that these curves have two distinct characteristics: a fluctuation (in some cases definitely periodic) superimposed on a constant slope. The fluctuation may be interpreted as being caused by a standing wave system either in the air or in the metal walls of the duct. The constant slope gives a measure of the exponential attenuation (since the relative pressure has been plotted on a logarithmic scale).

It was found that for frequencies greater than 1100 cycles per second the sound pressure at any given longitudinal position varied markedly from point to point in the transverse section of the duct, while for frequencies below 1100 cycles per second, the pressure was quite uniform over any given cross section. This condition is accounted for by the existence of systems of transverse standing waves, which is permitted only for frequencies greater than that whose wave length is twice the largest transverse dimension of the duct. This transverse variation of pressure made the interpretation of curves like those in Fig. 2 extremely difficult for frequencies greater than 1100 cycles per second. In order to circumvent this difficulty, it was decided to substitute a narrow band of continuously distributed frequencies for the single frequency used before. This procedure would *blur* the standing wave patterns, thus giving a more nearly uniform pressure distribution over any particular cross section, while at the same time it would preserve a certain amount of *resolution* with respect to frequency, so that the variation of attenuation with respect to frequency could still be determined.

This modification was accomplished in the following way: The beat frequency oscillator of Fig. 1 was replaced with a *shot-effect* random frequency generator, consisting of a high gain amplifier equipped with a fast-acting level compression circuit. The output of the system consists largely of amplified tube noise caused by discontinuities in the electron emission in the first tube of the amplifier. This noise is evenly distributed throughout the frequency spectrum; hence, the output sound signal contains all frequency components which lie within the pass band of the amplifier-speaker combination. The purpose of the compression circuit (or automatic volume control) was to minimize random changes in the output level which would cause the needle of the measuring instrument to fluctuate widely. The copper oxide voltmeter was replaced by a sound analyzer. This instrument selects a narrow band of frequencies (whose central frequency may be varied continuously) and indicates its relative pressure on a voltmeter calibrated directly in decibels. The width of the selected band is a constant percentage of the central fre-

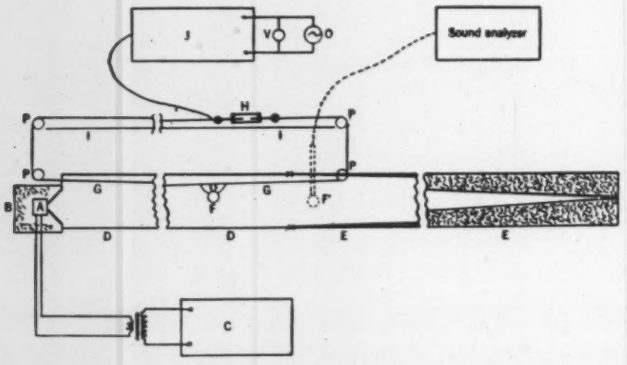


Fig. 1—Basic arrangement for determining attenuation in small ducts

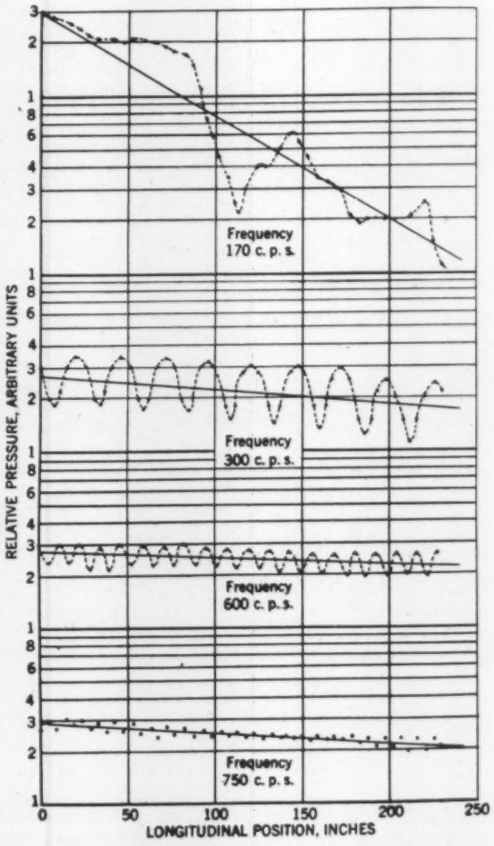


Fig. 2—Longitudinal variation of sound pressure in 6 in. x 6 in. duct (single frequency method)

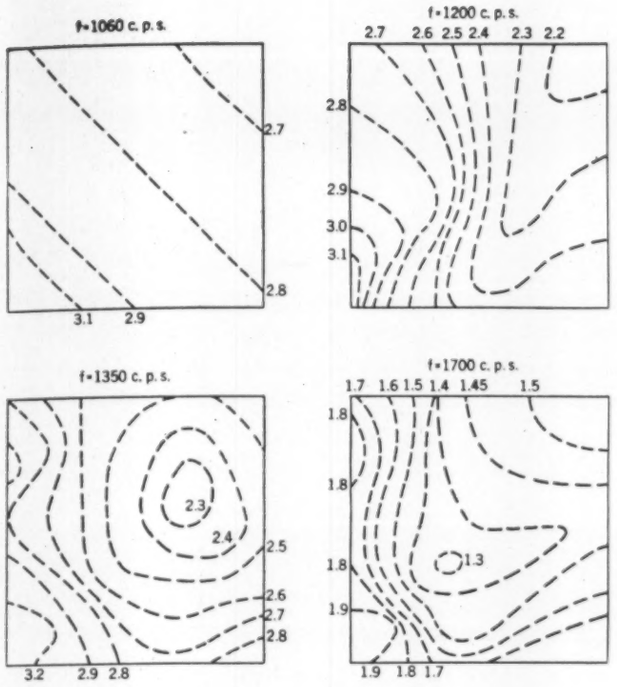


Fig. 3—Transverse distribution of pressure in a 6 in. x 6 in. duct

Dotted lines are sound isobars in transverse section of 6 in. x 6 in. duct. Numbers give relative sound pressure in arbitrary units.

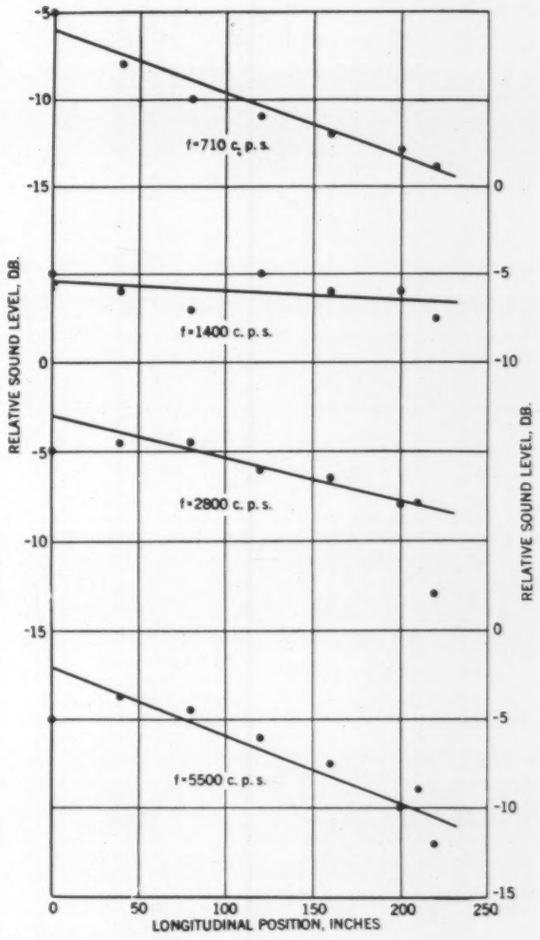


Fig. 4—Longitudinal variation of sound pressure in 6 in. x 6 in. duct (narrow band method)

quency over the entire range of the instrument. Some idea of the width of the band may be had from the statement that the sensitivity of the instrument at a frequency ten per cent higher or lower than the central frequency is approximately 10 db below the sensitivity at the central frequency.

With the apparatus thus modified, the probe microphone was temporarily dismounted from its cable, mounted on the end of a small brass tube, and inserted through the side of the conduit *E*, near the test duct, for the purpose of measuring the transverse pressure distribution. This arrangement is shown in dotted lines in Fig. 1, where the microphone is designated F^1. The brass tube contained the microphone cable, and was so mounted as to enable the microphone to be located anywhere in the transverse plane of the conduit. Relative pressure readings were taken over the transverse plane at several frequencies and representative curves are shown in Fig. 3. The variation in level was found not to exceed ± 1.5 db, which was considered satisfactory for the purpose of making longitudinal runs as was done with single frequencies below 1100 cycles per second.

The microphone was then remounted on the cable as before, and the procedure described for the single frequency measurements was followed. Since many frequencies were now present in the measurement signal, the longitudinal standing wave pattern was blurred and irregular, and there was no longer any reason to search out longitudinal maxima and minima. Points were taken at equally spaced positions, and the relative pressure plotted directly in decibels against longitudinal position, as in the representative curves of Fig. 4. The attenuation may be obtained from the average slope of the curve as was done in the case of the single frequency curves.

The method thus finally selected was satisfactory for the determination of attenuation as a function of frequency for small ducts. There remained the problem of extending it to large ducts. For this purpose a test section whose transverse dimensions were 12 in. x 36 in. and whose length was 20 ft was chosen. An absorbing conduit for the termination of such a duct was considered to be too unwieldy. Therefore, other means had to be used to provide a termination which would absorb a substantial part of the incident sound power. One way of accomplishing this was to terminate the duct in an infinite baffle. Then, for frequencies greater than a critical frequency (determined by the size of the duct opening) most of the energy arriving at the open end of the duct would be radiated into the space beyond the baffle. For the 12 in. x 36 in. duct the critical frequency was in the neighborhood of 200 cycles per second. These considerations were based on the classical analysis of a plane radiator vibrating in an infinite baffle. They were later verified by an independent experimental method.

To apply this method, the duct was terminated in an opening in the wall of the laboratory, as shown in Fig. 5. The remainder of the experimental arrangement was similar to that used on the 6 in. x 6 in. duct, except that the 4 in. dynamic speaker was replaced by one of 12 in. diameter. Data were obtained by the procedure outlined before, measurements being made with narrow bands of frequencies to average out the transverse standing

waves. Sample curves of relative pressure versus longitudinal position are shown in Fig. 6. Attenuation was again determined from the slope of a median straight line drawn between the points.

In order to check the validity of the assumption that reflection from the baffled end of the duct could be neglected at frequencies greater than 200 cycles per second, and also to extend the range of measurements down to lower frequencies, recourse was had to a method of producing a controllable terminating impedance developed by Bolt and Brown[2]. In broad outline, this method consists of terminating the duct in a network of lumped acoustical constants whose impedance may be made to have any desired value at any desired single frequency, within a wide range of both variables. In particular this network may be made to *match* the duct impedance, so that negligible reflection occurs at the chosen frequency. The particular form of network chosen for this investigation is shown in Fig. *7A*, and its equivalent electrical network in Fig. *7B*. The rock wool partition is a series combination of inertance and resistance, while the volume enclosed by the partition and the rigid wall at the duct end is an acoustic capacitance. At some frequency the net reactance will be zero, and if the remaining resistance is equal to the characteristic impedance of the duct the reflection from the partition into the duct will vanish. Since this termination is essentially a resonant system, its behavior is extremely sensitive to changes in frequency in the neighborhood of resonance where the reactance is zero. For this reason, it was decided to work with single frequencies, and accordingly, the random frequency generator was replaced with a primary oscillator, chosen for its frequency stability. Proper values of the partition thickness and air chamber volume were determined by trial since the effective resistance and inertance could not very well be calculated in advance. Also, during this investigation an alternative method of microphone support was tested. This consisted of hanging the microphone from two vertical supports mounted on a car equipped with rubber tired wheels. This car was driven through the duct by an endless cord passing over pulleys as in Fig. 1. The microphone cable then lay on the floor of the duct, being dragged behind the car. In this way the endless belt did not have to support the weight of the microphone, which was an advantage. On the other hand, the volume occupied by the car was many times greater than that of the microphone alone, and hence the diffraction effects were probably more serious; however, these could be neglected at the lower frequencies. Representative data taken with this arrangement are shown in Fig. 8, from which attenuation could be evaluated at frequencies below 200 cycles per second. Attenuation for frequencies above this value agreed with values obtained from data taken with the duct terminated in the infinite baffle, thus justifying this method at the higher frequencies.

[2]Variable Boundary Impedance for Room Acoustics Investigation, by Richard A. Bolt and Richard L. Brown. (*Journal of the Acoustical Society of America*, Vol. 12, July, 1940, p. 31).

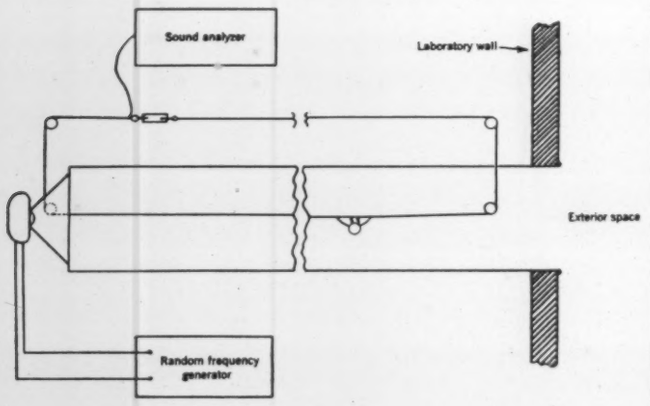


Fig. 5—Infinite baffle termination for large ducts

Conclusions

From the results of the tests previously described, some general conclusions about the method of measurement may be drawn.

1. Attenuation depends upon the frequency of the sound, and hence measurements must be made at different frequencies throughout the audible range.

2. Where the attenuation is small, measurements must be made throughout the length of the test duct. The attenuation may then be calculated from the slope of a median straight line drawn through the *center of gravity* of the points. Figs. 2, 4, and 6 show that under this condition, it is impossible to attempt to evaluate the attenuation merely from the ratio of the sound pressure at one end of the duct to that at the other end.

3. For small ducts an absorbing conduit affords a satisfactory termination, while

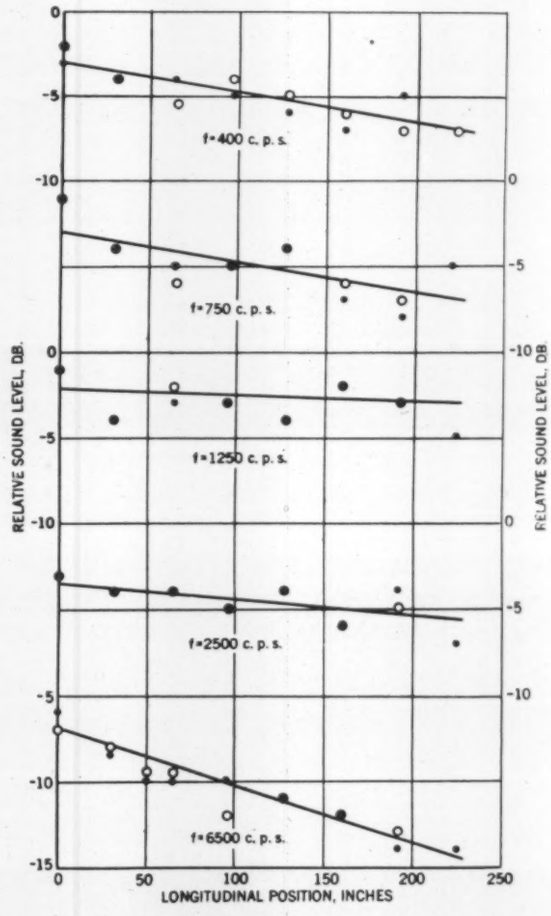


Fig. 6—Longitudinal variation of pressure in 12 in. x 36 in. duct (narrow band method)

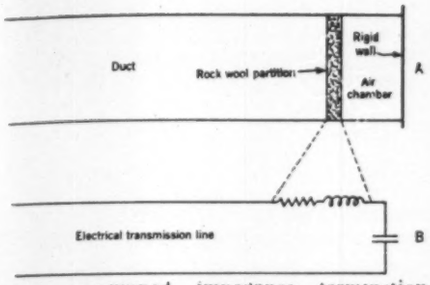


Fig. 7—Lumped impedance termination for large duct

for large ducts an infinite baffle satisfies the requirements.

4. A narrow band of frequencies is to be preferred to a single frequency when determining attenuation at a particular frequency. The loss in frequency resolution is more than compensated for by the elimination of confusion due to transverse standing waves.

5. The method previously described meets the conditions established in the first paragraph. When working with systems having low attenuation, some method such as this one, which satisfies these conditions, must be used to obtain reliable results. Also, this method may be used to check the reliability of simpler methods which may be used when the attenuation is larger.

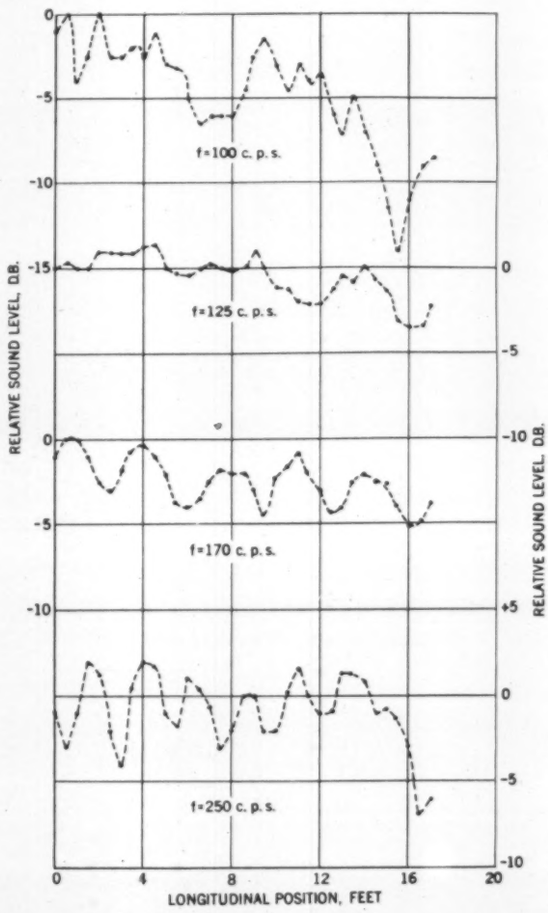


Fig. 8—Longitudinal variation of sound pressure in 12 in. x 36 in. duct (single frequency method)

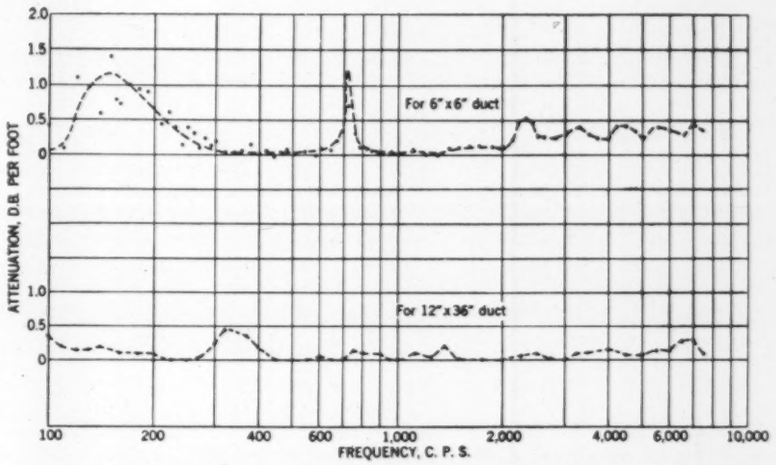


Fig. 9—Attenuation characteristics of straight unlined ducts

Attenuation in Unlined Ducts

If the attenuation per unit length in a duct is the same at all positions along the duct, the sound pressure, and hence intensity, in a progressive wave may be given by the equation

$$p = p_o e^{qx}$$

where

p = pressure at point x.
p_o = pressure at arbitrary origin.
x = position along the duct.
q = attenuation constant, in general a function of frequency.

When the logarithm of p is plotted against position, this equation reduces to a straight line, whose slope is q. In Figs. 2, 4 and 6 a median straight line has been drawn between the points, thus averaging out the contributions due to standing waves. In no case is there evidence that the median line is curved; thus there is every indication that the attenuation may be specified by a single constant at each frequency.

The values of q, in decibels per foot, as determined from the slopes of these median lines, are shown plotted against frequency in Fig. 9. The curve for the small duct shows that the attenuation is negligible below 2000 cycles per second except for two regions, one at 700 cycles per second and the other at 150 cycles per second. It was found that in these regions the walls of the duct vibrated as panels, thus radiating considerable power into the space surrounding the duct and, therefore, preventing it from being transmitted along the duct interior. Above 2000 cycles per second there is some measurable attenuation which did not seem to be associated with panel resonance. For the large duct the attenuation was everywhere negligible except in the regions 300-400 cycles per second. These frequencies were likewise associated with a group of panel resonances. On both the large and small ducts these panel resonances could be easily seen when fine sand was sprinkled on the top surface of the duct. If the frequency of the sound were continuously varied, the sand remained undisturbed until one of the resonance regions was entered. It then was set into motion, and if the sound were maintained, would pile up in the regions where the motion of the duct wall was least, thus defining the dynamic deformation pattern of the walls. These patterns were stable and reproducible, but highly irregular.

Since the same type of result was obtained with these two sizes of ducts, it is fair to assume that they are representative of all ducts whose sizes are intermediate between them. The general conclusion then is that for straight unlined ducts the attenuation is less than 0.2 decibel per foot, aside from certain narrow frequency regions where panel resonance may occur, and except for high frequencies in very small ducts.

DISCUSSION

C. M. ASHLEY, Syracuse, N. Y.: I think one of the most important contributions of the paper is in the technique involved in the test. For those who have done any test work of this sort, they must realize that there are serious technical problems in determining the attenuation, and I believe this work has gone quite a long way toward exploring the possibilities in that regard.

A second point which I would like to suggest is that I believe the work might be expanded by developing the principle that practically all of the sound loss, the attenuation, is due to transmission through the panels of the duct. Since duct panel transmission is fairly well known, I believe it would be possible to predict the effect for different size ducts, and different gauges of sheet metal with reasonable accuracy.

I might say for the committee that it is hoped that this work can be carried on into different types of connections, such as outlets, in sequence, and elbows, splitters, and various other things which are believed to have a very substantially larger attenuation than the duct itself.

H. K. KUNEN, New York, N. Y.: I believe one important point which should be investigated by the committee is the effect of air flow on sound attenuation in ducts. No doubt when air flows through any duct or conduit a sound wave is generated, due to the turbulent flow which creates currents. The sound generated should have an appreciable effect on the natural attenuation.

We have conducted a few experiments on various methods of sound control, together with the effect of attenuation in ducts, and we found that by having air flow through the duct at various velocities, results varied appreciably.

MR. SIMONS: In connection with Mr. Ashley's suggestion, mentioning the desirability of extending the method to the effects of elbows and take-offs and splitters, etc., that is now under consideration. We are engaged in investigating the effect of take-offs and of the ratio of the take-off to the main duct, one of the important parameters.

As far as the effect of air flow is concerned, that certainly is an important part of the problem. Obviously a method like this, involving an endless belt which has to be taken in and out of the duct, could not be used very easily where you have air moving through the duct; but you could use this method to check a second method which involves a stationary setting of the microphone in the moving air stream, then this second method could be used to measure the attenuation when air is flowing through the duct.

R. C. BOLSINGER DIES

Raymon C. Bolsinger, a member of the Society for 25 years, and long associated with the heating and ventilating industry in Philadelphia, died suddenly at Lititz, Pa. on April 14, 1942.

Mr. Bolsinger was born on February 18, 1884 at Ebensburg, Pa., where he received his early education. He served his apprenticeship in heating and ventilating with his brother J. S. Bolsinger from 1900 to 1905, at which time he became engineer and superintendent, remaining in that capacity until 1910. For the next two years he was associated with the Model Heating Co., Philadelphia, and in 1913 he was employed by the Fowler & Wolfe Manufacturing Co., serving in the capacity of secretary and sales manager. He became treasurer in 1929 and later president of the company.

R. C. Bolsinger

In June 1931 he joined the Automatic Florzone Heating Co., Conshohocken, Pa., and became president of the company in 1932.

Mr. Bolsinger designed several types of wall and tube radiators, as well as cast-iron fin radiators, and developed a special shunt fitting for one-pipe forced and gravity hot-water heating systems.

He joined the ASHVE in 1916 and was one of its most active and interested members. He was elected president of the Philadelphia Chapter in 1924, and served as a member of the Board of Governors in 1925. He was a member of the Technical Advisory Committee on Radiation in 1926, and that same year was in charge of arrangements for the Golf Meet held during the Society's Semi-Annual Meeting in Lexington, Ky. He was an ardent golfer and found great enjoyment in outdoor sports.

In 1930 he was general chairman of Committee on Arrangements for the 36th Annual Meeting in Philadelphia, at which time the 1st International Heating and Ventilating Exposition was held. In 1931 he served as a member of the Nominating Committee and in 1934 he was general chairman of Committee on Arrangements for the Semi-Annual Meeting at Buck Hill Falls, Pa.

He served as a member of the Society's Council from 1936 to 1938, and as chairman of the Membership Committee in 1937 and 1938.

Mr. Bolsinger was a figure well known and well liked among his fellow members in the Society and his loss will be keenly felt by his many friends and colleagues in the heating and ventilating field, many of whom saw him in January at the 48th Annual Meeting.

The Officers and Council of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS extend their sincere and heartfelt sympathy to his widow and family in their hour of sadness.

DEATH OF ARTHUR J. THOM

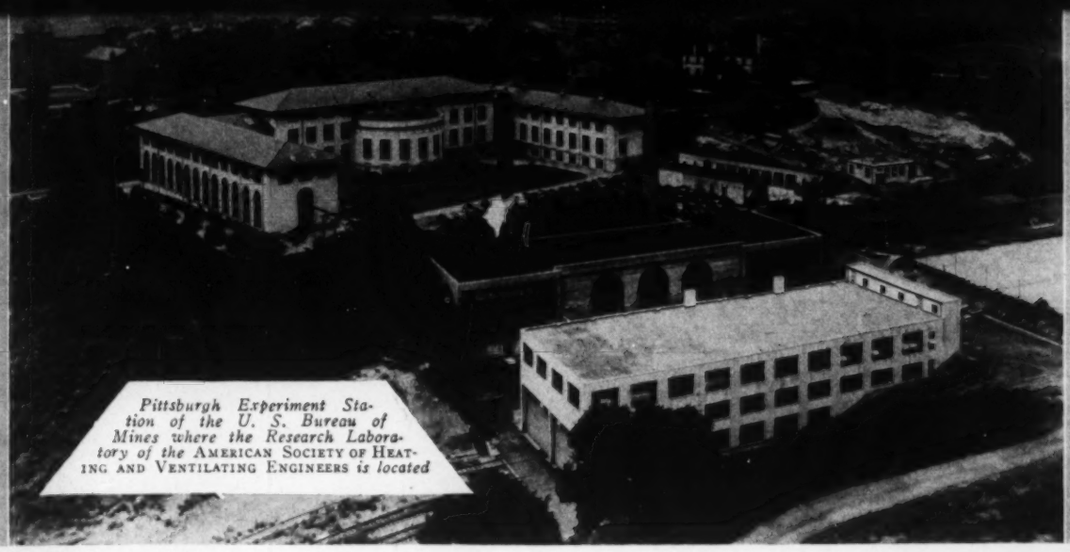
Word has just come to the Society of the death of Arthur J. Thom, who was instantly killed near Northfield, Wis., in an automobile accident on August 1, 1941.

Mr. Thom was employed by the Johnson Service Co., Milwaukee, where he was born September 25, 1912. After finishing at South Division High School in Milwaukee, he went to Madison where he majored in heating, ventilating and air conditioning at the University of Wisconsin under Professors G. L. Larson and D. W. Nelson. He was graduated from the University in 1938 with an M.E. and B.S. degree.

He started work with the Johnson Service Co., on June 27, 1938, and was assigned to the Milwaukee Branch as Sales Engineer, after a period in the Engineering Department.

In 1939 he married Miss Bernice Hanson, La Crosse, Wis. He is survived also by a baby daughter born after his death, on August 7, 1941. Mr. Thom was very well liked by his coworkers and the many contractors and engineers in the field whom it was his privilege to meet.

The Officers and Council of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS extend their sincere and deepest sympathy to his widow, and to his many friends in the Wisconsin Chapter.



Pittsburgh Experiment Station of the U. S. Bureau of Mines where the Research Laboratory of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS *is located*

Committee on Research

Annual Report

1941

A. E. Stacey, Jr.
Chairman

C.-E. A. Winslow
Vice-Chairman

T. H. Urdahl
Executive Committee

Axel Marin
Executive Committee

ONE OF the major accomplishments of the Committee on Research in 1941 was the preparation of a booklet, which was made available to the membership of the Society and other interested individuals. This publication contained for each of the 21 Technical Advisory Committees a comprehensive outline of carefully planned research investigations; regulations governing committee activities and a bibliography of research reports covering work emanating from the ASHVE Research Laboratory and cooperative institutions over a period of 22 years. The compilation of all this information was intended to serve as a basis for coordinating the future research program of the Society.

A total of 16 papers and 4 committee reports were presented to the Society this year, as a result of research sponsored currently in 13 cooperating institutions and the Society Research Laboratory. This research program was conducted through the several Technical Advisory Committees, which include 261 active persons who were responsible for studying the requirements for, outlining plans for the carrying out of, and reviewing the results of research for which the Society expended over $55,000.

Another investigation was completed this year on the effect of radiation in a panel heated room. Other studies have dealt with determinations of heat loss and gain through roofs, walls and basement floors. Additional projects have covered friction heads in fittings, entrainment action of air streams, sound attenuation in duct systems, performance of stack heads, pressure loss in elbows, and the thermodynamic properties of moist air. Through the financial support of the Atlanta Chapter, one of the cooperative institutions was able to complete a study on the cooling of a structure with an attic fan.

The individual committee reports which follow give detailed information covering investigations, either conducted at the ASHVE Laboratory or in cooperating institutions.

J. H. Walker
Technical Adviser

F. C. Houghten
Director

M. K. Fahnestock
Executive Committee

John James
Technical Secretary

Committee on Research

A. E. STACEY, JR., *Chairman*

C.-E. A. WINSLOW, *Vice-Chairman* — F. C. HOUGHTEN, *Director*

J. H. WALKER, *Technical Adviser* — A. C. FIELDNER, *Ex-Officio Member*

One Year

R. E. DALY — H. J. ROSE — C. TASKER

W. A. DANIELSON — C.-E. A. WINSLOW

Two Years

PHILIP DRINKER — A. E. STACEY, JR. — J. H. VAN ALSBURG — J. H. WALKER

AXEL MARIN

Three Years

C. M. ASHLEY — H. KING MCCAIN — F. C. MCINTOSH

M. K. FAHNESTOCK — T. H. URDAHL

Executive Committee

A. E. STACEY, JR., *Chairman*

M. K. FAHNESTOCK — AXEL MARIN — T. H. URDAHL — C.-E. A. WINSLOW

Finance Committee

E. P. HECKEL, *Chairman*

E. K. CAMPBELL — H. B. HEDGES — A. F. NASS — C. H. RANDOLPH

Technical Advisory Committees

Sensations of Comfort, 1

Thomas Chester, *Chairman;* N. D. Adams, C. R. Bellamy, G. D. Fife, E. P. Heckel, Dr. W. J. McConnell, F. C. McIntosh*, A. B. Newton, B. F. Raber, C. Tasker*.

During the year a digest was prepared of eleven papers dealing with atmospheric conditions conducive to summer comfort in air conditioned enclosures, completing work which had been commenced during the previous year. This committee report entitled, Comfort with Summer Air Conditioning, will be presented at the 1942 Annual Meeting.

Due to the ASHVE Research Laboratory at Pittsburgh having been fully engaged in important government work and investigations under the auspices of other Technical Advisory Committees, the program prepared sometime ago relative to research for the purpose of eliminating obscurities surrounding important factors which affect sensations of comfort has not been initiated. It is hoped that progress will be made on this project when time and funds are available.

Physiological Reactions, 2

C.-E. A. Winslow*, *Chairman;* Dr. T. Bedford, Thomas Chester, Dr. E. F. DuBois, Dr. M. B. Ferderber, E. P. Heckel, John Howatt, Dr. R. W. Keeton, C. S. Leopold, André Missenard, Dr. R. R. Sayers, Charles Sheard, C. Tasker*.

The chief work of the Committee as a whole has been the preparation of a report on the influence of atmospheric humidity on human health and comfort. This report is to be presented at the 1942 Annual Meeting of the Society. It summarizes the present status of knowledge with regard to the influences of atmospheric humidity, upon heat losses from the human body at high and low temperatures, respectively, and also with regard to the dehydrating effect of various atmospheric conditions upon the membranes of the nose and throat.

The University of Illinois, College of Medicine, has undertaken a study of the physiological adjustments, which follow the sudden entrance of an individual into an atmospheric environment of widely different heat properties from the one to which he was previously adjusted. At present the investigators are considering the sudden change from a comfortable to a hot moist environment (dry-bulb 99-100 F, wet-bulb 86-90 F). The period of adjustment is measured by the time required for the skin temperature of selected areas to become stable. Frequent records of electrocardiographic tracings have shown negligible changes in *T* waves. At present attention is concentrated on the venous pressure changes. On the sudden exposure to hot moist environments there is a distinct feeling of discomfort often accompanied by faintness and dizziness. In some sensitive individuals, with a sudden change in the position syncope results. Preceding syncope the arterial blood pressure falls rapidly and the heart beat is increased greatly. These changes have been attributed to an inadequate return of blood to the heart and to its accumulation in the venous channels. It was felt that if a satisfactory explanation could be obtained for this syncope, then the less marked changes attended by dizziness and discomfort could be more satisfactorily interpreted. At present healthy medical students are being used as subjects. It is planned to extend the observations to apparently healthy older individuals, and later to individuals with well compensated heart disease.

*Member of Committee on Research.

Air Conditioning in Industry, 3

W. L. Fleisher*, *Chairman;* Dr. Leonard Greenburg, H. P. Greenwald, W. C. L. Hemeon, A. M. Kinney, J. W. Kreuttner, L. L. Lewis, H. B. Matzen, Dr. W. J. McConnell, Dr. C. P. McCord, P. A. McKittrick, Dr. R. R. Sayers, Charles Sheard, C. Tasker,* R. M. Watt, Jr., H. E. Ziel.

The principal work accomplished this year has been rather exhaustive tests in spot cooling with different temperatures, humidities and velocities, to determine whether, by introducing air at conditions below the skin temperature, relief could be afforded workmen who are in such intensely hot industries, that the conditioning of the entire enclosure is not feasible.

Although actual tests were not conducted to determine the reaction of women workers engaged in industrial activities, the relative effect of the same ambient condition on men and women has been observed to a certain extent in other investigations conducted at the ASHVE Research Laboratory this year from which conclusions may be drawn.

Some progress has been made on an investigation to determine critical conditions of the atmosphere at low relative humidities, with special emphasis on the fatigue of leucocytes in connection with high temperatures and low humidities.

Removal of Atmospheric Impurities, 4

Dr. Leonard Greenburg, *Chairman;* J. J. Burke, J. M. DallaValle, R. S. Dill, Theodore Hatch, L. R. Koller, F. H. Munkelt, H. C. Murphy, G. W. Penney, Dr. E. B. Phelps, F. B. Rowley, C. Tasker,* W. O. Vedder, J. H. Waggoner, R. P. Warren, W. F. Wells, Dr. Renée Wiener.

The program of this committee entails the preparation of a comprehensive outline of work already done in the field, collecting known data and summarizing it for interpretation by the engineer, and indicating gaps of knowledge for which subsequent research may be conducted.

The work is divided into three divisions formulated to deal

Contributors to Research

Contributions in support of the research work of the Committee on Research are hereby acknowledged:

Financial Contributions

Aerofin Corp.; *Air Conditioning Association of Cleveland;* American Air Filter Co., Inc.; American Radiator & Standard Sanitary Corp.; Anemostat Corporation of America; Atlanta Chapter of ASHVE; Auer Register Co.; Automatic Burner Corp.; Barber-Colman Co.; Bell & Gossett Co.; Buffalo Forge Co.; A. M. Byers Co.; Carrier Corp.; Consolidated Gas Electric Light & Power Company of Baltimore; Crane Co.; Detroit Edison Co.; Thomas M. Dugan; Frick Co., Inc.; G & O Mfg. Co.; General Electric Co.; Georgia Power Co.; Hart & Cooley Mfg. Co.; *Heating, Piping & Air Conditioning Contractors National Association;* Hoffman Specialty Co.; Ilg Electric Ventilating Co.; Illinois Testing Laboratories, Inc.; *Insulation Board Institute;* Johns-Manville Corp.; Johnson Service Co.; Kinetic Chemicals, Inc.; Minneapolis-Honeywell Regulator Co.; Mueller Brass Co.; Narowetz Heating & Ventilating Co.; Nash Engineering Co.; National Radiator Co.; New York Steam Corp.; Owens-Illinois Glass Co.; Permutit Co.; Philadelphia Electric Co.; Pittsburgh Corning Corp.; Sarco Co., Inc.; Staynew Filter Corp., Surface Combustion Corp.; Taylor Instrument Companies; Trane Co.; Union Electric Company of Missouri; Utica Radiator Corp.; Warren Webster & Co.; Weil-McLain Co.; Westinghouse Electric & Mfg. Co.; L. J. Wing Mfg. Co.; Worthington Pump and Machinery Corp.; York Ice Machinery Corp.

Donors of Equipment or Material

American Radiator & Standard Sanitary Corp.; Barber-Colman Co.; Bell & Gossett Co.; Burnham Boiler Corp.; A. M. Byers Co.; Detroit Lubricator Co.; Eagle-Picher Lead Co.; Excelsior Steel Furnace Co.; Exposition Cotton Mills; Julien P. Friez & Sons; Furblo Co.; Gloninger Brick Co.; Hart & Cooley Mfg. Co.; Independent Register Co.; International Heater Co.; Johnson Service Co.; Koppers Co.; Lamneck Products, Inc.; Lau Blower Co.; Modine Mfg. Co.; Owens-Corning Fiberglas Corp.; Structural Clay Products Institute; Tuttle & Bailey, Inc.; Waterloo Register Co.

Periodicals

Air Conditioning and Oil Heat; American Artisan; Canadian Engineer; Domestic Engineering; The Engineer (London); *Heating, Piping and Air Conditioning; Heating and Ventilating; Ice and Refrigeration; Journal of Institution of Heating and Ventilating Engineers* (London); *Plumbing and Heating Journal.*

with the special aspects of the problem, which include mechanical, chemical and bactericidal methods of purification.

1. *Mechanical Purification.* The collection of factual data covering various types of dusts encountered in industrial operations at the point of production. Samples to be submitted to careful microscopic particle size determinations and separated into various classifications as follows: (*A*) Under 20 microns; (*B*) Under 10 microns; (*C*) Under 1 micron.

It is planned to extend this work until sufficient data have been obtained to represent a satisfactory picture of the usual type of industrial dust producing processes and filtration devices.

2. *Chemical Purification.* Such processes involving adsorption, decomposition, oxidation and reaction are considered herein as chemical methods of purification. The use of chemical processes for air purification is limited properly to gas and vapor impurities. However, chemical means may be used to prevent contamination of air by gases from solid or liquid matter, such as chlorination or liming of fetid or decaying matter and it may be that some method of this type will require the attention of the committee in the future. Four methods of chemical air purification are being studied: Adsorption by activated carbon, oxidation by ozone, washing with spray water containing such chemicals as chlorine or caustics in solution, and vaporization, or volatilization, or atomization of chemicals in air.

3. *Bactericidal Purification.* The development of literature and the clinical examination of experimental data involving the utilization of ultra violet radiation sources.

Radiation and Comfort, 5

J. C. Fitts, *Chairman;* **A. H. Barker, L. M. K. Boelter, R. E. Daly,* J. B. Fullman, E. R. Gurney, L. N. Hunter, A. P. Kratz, C. S. Leopold, D. W. Nelson, W. J. Olvany, G. W. Penney, W. R. Rhoton, C. J. Stermer, C.-E. A. Winslow.***

This committee was formed in 1938 for the purpose of considering all problems related to radiation as it affects human comfort in winter and summer. From an outline of basic researches prepared, the committee initially decided to concentrate on a laboratory investigation to determine the primary sense reactions of relative comfort derived from rooms heated by convection and direct radiation, and with normal window arrangements.

During the summer of 1939 the necessary building was erected at the ASHVE Research Laboratory in Pittsburgh, and throughout the winter tests were conducted, the results of which were submitted in a paper at the 1941 Annual Meeting.

Subsequently, one of the test rooms in the building was equipped with ceiling panels constructed of sinuous coils through which hot water was circulated to provide all of the heating requirements. Tests conducted through the winter of 1940-41 resulted in a second paper dealing with radiation as a factor in the feeling of warmth in convection, radiator and panel heated rooms, which is to be presented at the 1942 Annual Meeting.

In addition, the committee has been responsible for directing a cooperative research project at the University of California, which is intended to develop a more rational basis for the design of panel heating and cooling systems. A progress report covering this work is also being presented at the 1942 Annual Meeting.

Instruments, 6

D. W. Nelson, *Chairman;* **F. R. Bichowsky, L. M. K. Boelter, R. S. Dill, A. P. Gagge, J. A. Goff, A. E. Hershey, F. C. McIntosh,* F. W. Reichelderfer, G. L. Tuve, C. P. Yaglou.**

Progress has been made this year in establishing standards for measuring the physical properties of the thermal environment: namely, relative humidity, ambient air temperature, air

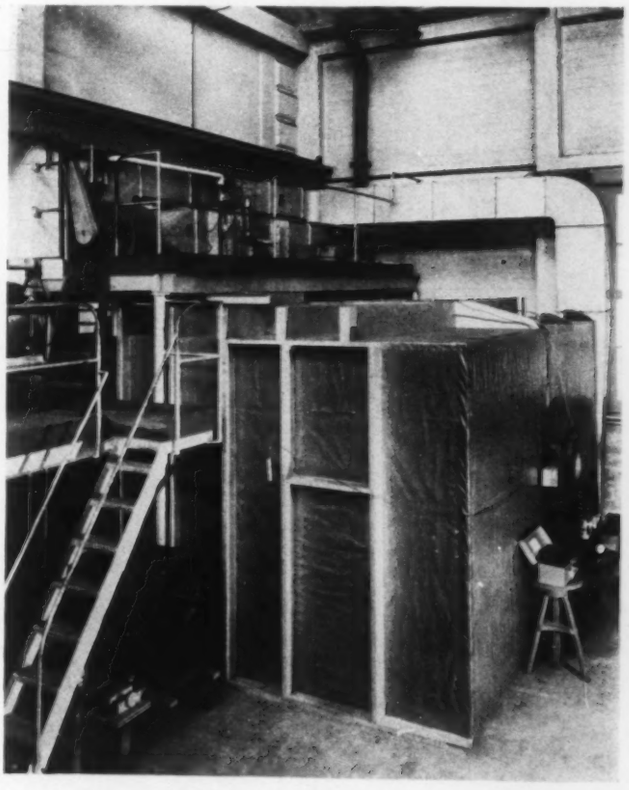


Fig. 1—Equipment for investigating panel heating and cooling systems, University of California

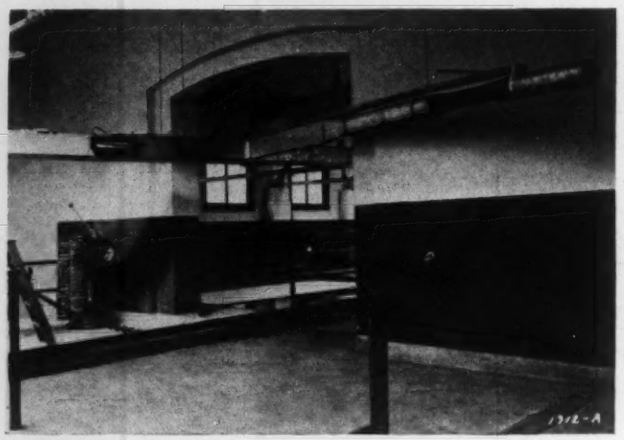


Fig. 2—Determining friction loss in duct transitions, Michigan State College

movement and mean radiant wall temperature. The committee has agreed on the measurement of these items and expects to have a report available in the near future.

Much work has been accomplished on the measurement of radiant temperatures. While recognizing that investigations in progress may alter the situation, the committee is prepared to agree on the blackened globe thermometer in 8 in. size for measuring the mean radiant temperature. Its use is based on the principle that radiant energy is exchanged between its spherical surface and all surfaces it *sees* and it loses heat by convection at a rate dependent on this energy reception, the ambient temperature and the air movement at its location. A more direct method, the use of the thermopile, measures radiant temperatures of each surface directly but is tedious to use because of the many readings required and the necessary integration to obtain the answer related to an object such as the human body.

The means of measuring low velocity air currents as encountered in heated and cooled rooms is receiving considerable attention at the present, with most emphasis being placed on some form of thermo anemometer, such as the hot wire anemometer. Several methods of calibration are being attempted in the various laboratories doing society cooperative research in the field of air distribution, radiant heating and other projects involving the thermal environment. The wind tunnel seems to be first in favor with the whirling arm and the gasometer also being investigated. The problem appears to be to obtain a known linear air motion in the test section for calibration and relate that to the non-linear or miscellaneous free motion in the room air to be measured.

Weather Design Conditions, 7

T. H. Urdahl,* *Chairman;* **J. C. Albright, H. S. Birkett, P. D. Close, John Everetts, Jr., C. M. Humphreys, O. A. Kinzer, H. H. Koster, J. W. O'Neill, F. W. Reichelderfer.**

During the past year cooperative work has been initiated in Washington, D. C. to determine temperature differences existing between business and suburban sections. Several recording stations were selected at representative points in the city, taking into consideration the geological characteristics of the locality. Simultaneous readings obtained with the official Weather Bureau record were observed to establish a percentage of variations for the various sections of the city selected for observation. The conduct of this work in Washington will enable the development of a procedure which may be applied to other localities, in order to obtain these data for each representative city. In this work the cooperation of local utilities, colleges and universities, and especially local Society Chapters has been earnestly sought to provide the personnel required for making the observations.

Radiation with Gravity Air Circulation, 8

M. K. Fahnestock,* *Chairman;* **R. E. Daly,* R. S. Dill, A. G. Dixon, H. F. Hutzel, J. P. Magos, J. W. McElgin, J. F. McIntire, T. A. Novotney, W. A. Rowe.**

The work of this committee during the past year at the University of Illinois and in other cooperating laboratories was a continuation of a program started in 1940 which included:

1. Studies to determine the influence of a cold-wall test room and a warm-wall test booth on the performance of radiators and convectors, and the development of test methods which would give similar output ratings with each type of test equipment. Two direct cast-iron radiators, one cast-iron convector, and one non-ferrous convector were tested in the cold room and in the warm-wall booth at the University of Illinois.

2. A study of tests conducted with the same radiators and convectors in a number of different laboratories for the purpose of improving test methods and developing test equipment which would make possible more uniformity in test results. This

Research Papers—1941

Cooperative Institutions

1. The Interaction Constant for Moist Air, by John A. Goff and A. C. Bates (Pennsylvania) (July 1941, JOURNAL).
2. Economical Air Velocities for Mechanical Air Filtration, by Frank B. Rowley and Richard C. Jordan (Minnesota) (August 1941, JOURNAL).
3. Performance Characteristics of a Forced Draft, Counterflow Spray Cooling Tower, by Howard H. Niederman, E. D. Howe, John P. Longwell, Ralph A. Seban and L. M. K. Boelter (California) (September 1941, JOURNAL).
4. Pressure Loss Caused by Elbows in 8-inch Round Ventilating Duct, by M. C. Stuart, C. F. Warner and W. C. Roberts (Lehigh) (October 1941, JOURNAL).
5. Entrainment and Jet-Pump Action of Air Streams, by G. L. Tuve, G. B. Priester and D. K. Wright, Jr. (Case) (November 1941, JOURNAL).
6. The Performance of Stack Heads Equipped with Grilles, by D. W. Nelson, D. H. Lamb and G. E. Smedberg (Wisconsin) (Annual Meeting, January 1942).
7. Development and Application of a Method for Determining Sound Attenuation in Air Conditioning Systems, by D. A. Wilbur and R. F. Simons (Rensselaer) (Annual Meeting, January 1942).
8. The Effect of Attic Fan Operation on the Cooling of a Structure, by W. A. Hinton and Albert F. Poor (Georgia Tech.) (Annual Meeting, January 1942).
9. Panel Heating and Cooling Performance Studies, by B. F. Raber and F. W. Hutchinson (California) (Annual Meeting, January 1942).
10. A Comparative Study of the Friction-Heads in Screwed and Welded Elbows, by F. E. Giesecke and J. S. Hopper (Texas) (Annual Meeting, January 1942).
11. The Vapor Pressure of Ice from 32 to —280 F, by John A. Goff (Pennsylvania) (Annual Meeting, January 1942).

ASHVE Laboratory

12. Local Cooling of Workers in Hot Industry, by F. C. Houghten, M. B. Ferderber and Carl Gutberlet (July 1941, JOURNAL).
13. A Review of Glass Transmittance Coefficients, by F. C. Houghten, M. L. Carr and David Shore (November 1941, JOURNAL).
14. Radiation as a Factor in the Feeling of Warmth in Convection, Radiator and Panel Heated Rooms, by F. C. Houghten, Carl Gutberlet and E. C. Hach (December 1941, JOURNAL).
15. Heat Gain Through Walls and Roofs as Affected by Solar Radiation, by F. C. Houghten, E. C. Hach, S. I. Taimuty and Carl Gutberlet (Annual Meeting, January 1942).
16. Heat Loss Through Basement Walls and Floors, by F. C. Houghten, S. I. Taimuty, Carl Gutberlet and C. L. Brown (Annual Meeting, January 1942).

Technical Advisory Committees

17. Comfort with Summer Air Conditioning, by Technical Advisory Committee on Sensations of Comfort, Thomas Chester, Chairman (October 1941, JOURNAL).
18. The Physiological Influence of Atmospheric Humidity, by the Technical Advisory Committee on Physiological Reactions, C.-E. A. Winslow, Chairman (December 1941, JOURNAL).
19. Corrosion Tests in a Water-Recirculating Air Conditioning System, by W. Z. Friend (Sponsored by Technical Advisory Committee on Corrosion) (Annual Meeting, January 1942).
20. Measurement of the Physical Properties of the Thermal Environment, by Technical Advisory Committee on Instruments, D. W. Nelson, Chairman (Available mimeographed form).

work involved tests with two cast-iron radiators, two cast-iron convectors, and one non-ferrous convector in three cold rooms, three cold-wall test rooms, and three warm-wall test booths. The tests have been completed in three cold rooms, in one cold-wall test room, and in two warm-wall test booths located in different laboratories.

3. A study of the effect of the ambient air temperature on the performance of radiators and convectors tested in rooms surrounded by cold spaces. Tests have been completed with two cast-iron radiators, two non-ferrous convectors, and one cast-iron convector in the cold room at the University of Illinois, with temperatures in the spaces surrounding the cold room ranging from minus 5 to plus 12 F.

A second warm-wall test booth and auxiliary equipment are being provided for a study of the performance of convectors and radiators when used with hot water. It is proposed to conduct tests with one cast-iron convector, one non-ferrous convector, and one small-tube cast-iron radiator, and to determine the fluid pressure loss and the heat output for each unit under each operating condition. The operating conditions will include mean water temperatures of 140, 170, 200, and 210 F, and water temperature drops of 5, 10, and 15 F for each mean water temperature. Tests will be made with ½ in. piping connections and with connections the same size as the tapping in the heaters. Both sizes of connections will be used with end supply and return and with underneath supply and return piping arrangements.

Heat Transfer of Finned Tubes with Forced Air Circulation, 9

W. E. Heibel, *Chairman;* C. M. Ashley,* William Goodman, H. F. Hutzel, Ferdinand Jehle, S. F. Nicoll, R. H. Norris, L. P. Saunders, R. J. Tenkonohy, G. L. Tuve, C. F. Wood.

One function of this committee has been to develop fundamental data so that more accurate coefficients could be established for testing and calculating sizes of finned tubes. Studies outlined during the current year include:

Determination of minimum refrigerant temperature for operathrough water films existing on the external surface of finned tubes of various types.

Determination of minimum refrigerant temperature for operation of finned tubes above the frost line on the air side of the coil.

A study of the performance of finned tubes under operation with volatile and non-volatile refrigerants.

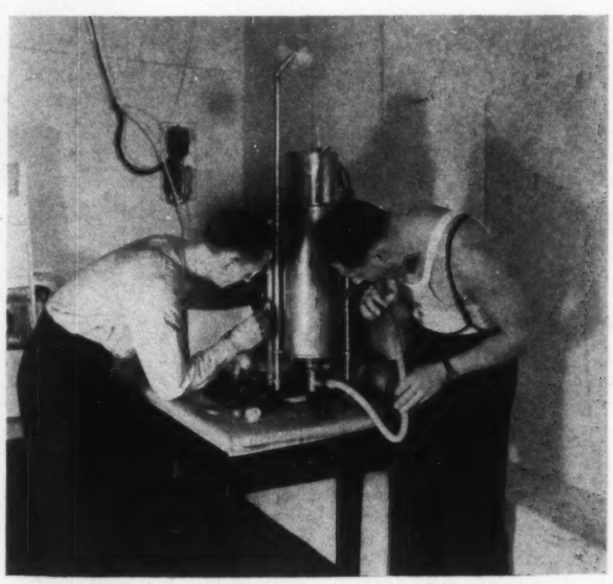


Fig. 3—Determination of vital capacity of subject working in hot atmospheres, ASHVE Research Laboratory

Institutions Cooperating with the Committee on Research

Agricultural & Mechanical College of Texas
Frictional Flow of Water in Pipes and Elbows
Heating Requirements of Buildings

University of California
Performance of Cooling Towers
Radiant Heating and Cooling

Case School of Applied Science
Air Distribution in Air Conditioned Spaces

Georgia School of Technology
Cooling of a Structure with Attic Fans

University of Illinois, Engineering
Radiator and Convector Studies
Residence Summer Air Conditioning
Air Distribution Outlets

University of Illinois, Medical School
Human Responses to Physiological Reactions

Lehigh University
Frictional Resistance to the Flow of Air Through Elbows

Michigan College of Mining & Technology
Corrosion in Steam Heating Systems

Michigan State College
Air Flow in Duct Transitions

University of Minnesota
Methods of Rating Air Cleaning Devices

University of Pennsylvania
Measuring Departures from Dalton's Law of Air-Water Vapor Mixtures

Rensselaer Polytechnic Institute
Sound Transmission in Ducts

University of Wisconsin
Effect of Entering Air Temperature and Velocity on Distribution of Air in Enclosed Spaces

A study of the effect of temperature, both on the air side and on the heating or cooling medium side of the surface.

Standardization in terminology, symbols and arrangement of data should be established.

Standardized types of instruments should be selected, including: temperature, electrical, humidity, pressure, air flow, refrigerant, time and weight measuring devices.

Cooling Load in Summer Air Conditioning, 10

C. M. Ashley*, *Chairman;* John Everetts, Jr., E. H. Hyde, C. S. Leopold, C. O. Mackey, R. M. Stikeleather, J. H. Walker, W. E. Zieber.

A report giving the twenty-four hour heat gain rates for 11 walls and 18 roofs, having wide variation in resistance to heat flow and capacity, will be presented at the 1942 Annual Meeting, as a contribution of this committee. The data presented in this paper are considered important as an initial contribution toward a more accurate method of determining the cooling load of a structure. Further study of the data is necessary to determine how the observed heat flows compare with the theory relating heat flow to the orientation, heat capacity, transmittance coefficient and absorptivity of solar radiation by the outside surface of the structure.

The committee program also includes problems relating to infiltration through open, swinging and revolving doors, as well as the important question of establishing more accurate heat gain data from gas, electric and steam appliances.

Summer Air Conditioning for Residences, 11

M. K. Fahnestock*, *Chairman;* C. F. Boester, E. A. Brandt, John Everetts, Jr., H, F. Hutzel, E. D. Milener, K. W. Miller, F. G. Sedgwick, J. H. Walker*.

While no active research work was done under the auspices of this committee during the summer of 1941, a comprehensive program of future investigation was outlined. The erection of a new research home at the University of Illinois makes available a completely equipped residence varying in size and type of construction from the home used for previous investigations.

The new residence has six medium sized rooms. The brick-

Fig. 4—Apparatus for determining elbow friction losses, Lehigh University

veneer exterior walls and the second floor ceiling are insulated with full thickness insulation. In addition to repeating some of the work which has been conducted in the eight room wood frame house, work in the new house might include:

1. Studies to determine the practical effectiveness of various window appurtenances in reducing the cooling load.

2. Studies to determine the practical effectiveness of storm windows, double glazed windows, and windows of special glass on the cooling load.

3. Studies to determine the difference in the comfort of a small home, first, when the attic is kept closed continuously, and second, when it is ventilated continuously by gravity through built-in louvers or windows.

4. Studies to determine the capacity of attic fans to be used to obtain reasonable and practical benefits from the circulation of outdoor air at night.

5. Studies to determine the feasibility and practicability of using one or more mechanical unit room coolers to cool a small residence.

Air Distribution and Air Friction, 12

J. H. Van Alsburg*, *Chairman;* **S. H. Downs, A. E. Hershey, R. D. Madison, L. G. Miller, D. W. Nelson, C. H. Randolph, D. J. Stewart, M. C. Stuart, Ernest Szekely, R. J. Tenkonohy, G. L. Tuve.**

Five years of continuous activity by this committee on problems related to air distribution and air friction has reached a point during the past year where investigations were being conducted not only at the ASHVE Research Laboratory, but also in five cooperating institutions.

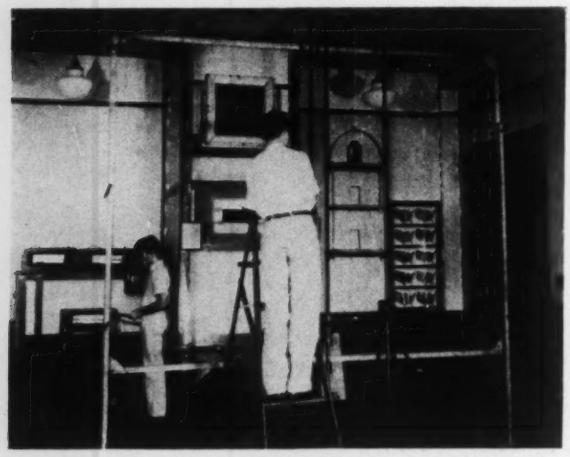


Fig. 5—Investigating air streams delivered by rectangular supply grilles, Case School of Applied Science

Studies on the frictional resistance to the flow of air in round pipes has been completed at the Society Laboratory and results of tests on square and rectangular ducts are planned for presentation at the 1942 Semi-Annual Meeting. A paper covering the pressure losses in round elbows as the result of cooperative research with Lehigh University, will be presented at the 1942 Annual Meeting. Future investigations at this institution have been planned to develop data on the pressure losses, resulting from turning vanes placed in elbows. The resistance of duct transitions and Y fittings is the subject of an investigation being conducted at Michigan State College.

In the field of air distribution a paper on the performance of stack heads equipped with grilles will also be presented at the 1942 Annual Meeting, covering work recently completed at the University of Wisconsin. As a result of cooperative research at the Case School of Applied Science, another paper on the entrainment and jet-pump action of air streams will be available for the 1942 Annual Meeting.

Another project on air distribution, involving the affect of inlet and exhaust opening location on the motion of air within a room, is being actively investigated at the University of Illinois. It is expected that results from this study will be released for publication in the near future.

Heat Requirements of Buildings, 13

P. D. Close, *Chairman;* **E. K. Campbell, J. F. Collins, Jr., E. F. Dawson, W. H. Driscoll, H. M. Hart, E. C. Lloyd, H. H. Mather, C. H. Pesterfield, F. B. Rowley, R. K. Thulman, J. H. Walker*.**

A study of basement heat losses has been in progress at the ASHVE Research Laboratory in Pittsburgh during the past year and as a result of this study a paper entitled, Heat Loss through Basement Walls and Floors, will be presented at the 1942 Annual Meeting. These tests were conducted in a simulated basement 15 x 15 x 8 feet high, built on the premises of the Bureau of Mines in Pittsburgh. This report should furnish a basis for revision of the GUIDE data on calculation of basement heat losses and also add valuable data on the prevention of condensation on basement walls. However, it appears from this research report that a further study of the subject is desirable.

Two other papers dealing with heat requirements of buildings have also been prepared under the sponsorship of this committee. One of these entitled, An Analysis of Factors Influencing Building Heat Losses, was presented at the 1941 Semi-Annual Meeting of the Society. The other paper entitled, Attic Temperatures, Ventilation and Heat Losses, will be published in the near future and is intended to throw some light on a phase of the heat loss problem to which little consideration has been given until recently.

At the request of the Society's Joint Committee to Study Uniform Methods of Heat Loss Calculation, consideration is being given by this committee to the preparation of a condensed manual for heat loss calculations based on the GUIDE procedure, but is not intended to replace the more accurate GUIDE method.

Air Conditioning Requirements of Glass, 14

M. L. Carr, *Chairman;* **C. M. Ashley*, L. T. Avery, F. L. Bishop, D. A. Bridges, W. A. Danielson*, H. C. Dickinson, J. D. Edwards, J. E. Frazier, S. O. Hall, E. H. Hobbie, C. L. Kribs Jr., Axel Marin*, R. A. Miller, F. W. Parkinson, W. C. Randall, L. T. Sherwood, J. T. Staples, G. B. Watkins, F. C. Weinert.**

No meetings were held by this committee in 1941, but one proposed activity was considered by correspondence early in the year and it was later decided to drop the project until adequate laboratory facilities could be arranged.

During the year a paper was published resulting from the work

of this committee, which included a review of glass transmittance coefficients. The results of the several studies cited in this paper indicated that the transmittance coefficients for glass varied over a wide range. It was found that the reported variations could not be satisfactorily correlated with peculiarities in installation, nor could they be with such test conditions as the air velocity over the test surface, the method of heat input, the size of the panel tested or the location and the method of temperature measurement. It was felt that these reported studies would serve as a basis for outlining a future and more comprehensive study of the entire project.

A suggestion has been received to continue the study of heat transmission through flat glass and single and double glazing in the near future.

Insulation, 15

R. T. Miller, *Chairman;* **E. A. Allcut, R. E. Backstrom, Wharton Clay, R. E. Daly*, H. C. Dickinson, J. D. Edwards, W. V. Hukill, E. C. Lloyd, Paul McDermott, E. W. McMullen, W. T. Miller, E. R. Queer, F. B. Rowley, W. S. Steele, J. H. Waggoner, G. B. Wilkes.**

Plans have been formulated for investigating three projects which are of special interest to this committee. One deals with additional studies to determine the conductances of various air spaces bounded with reflective materials. Another project involves a careful investigation covering the conductivity of materials subjected to variable heat flow. It is also felt that additional research is desirable to determine the heat capacity of various building and insulating materials.

Sound Control, 16

J. S. Parkinson, *Chairman;* **C. M. Ashley*, A. L. Kimball, V. O. Knudsen, R. D. Madison, R. F. Norris, C. H. Randolph, A. E. Stacey, Jr.*, A. G. Sutcliffe, Thomas A. Walters, R. M. Watt, Jr.**

The research program of this committee has been designed to procure fundamental data in order to establish background noise levels encountered in air conditioned spaces.

Cooperative work with Rensselaer Polytechnic Institute was continued this year to obtain additional information for predicting sound attenuation through a duct system. A paper covering the application of a method for determining sound absorption in a duct system developed at this institution will be presented at the 1942 Annual Meeting.

A tentative testing procedure has been developed by the committee for measuring the amount of noise generated by equipment. The committee is encouraging individual experimentation to check the principles outlined in this standard, in order that necessary revisions to the procedure may be subsequently considered.

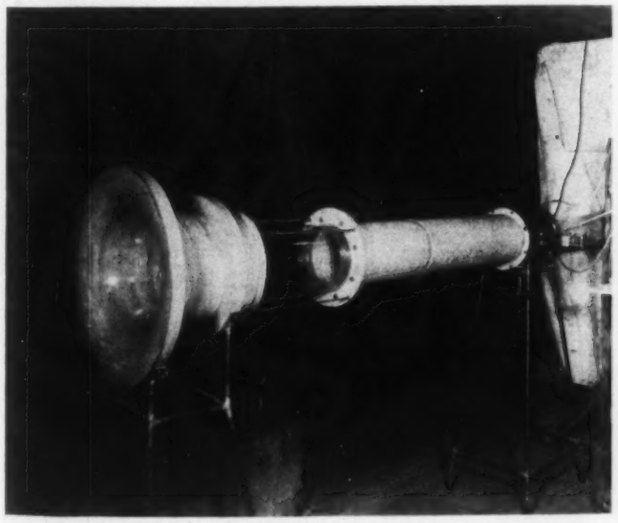


Fig. 6—Wind tunnel for calibrating anemometers, University of Illinois

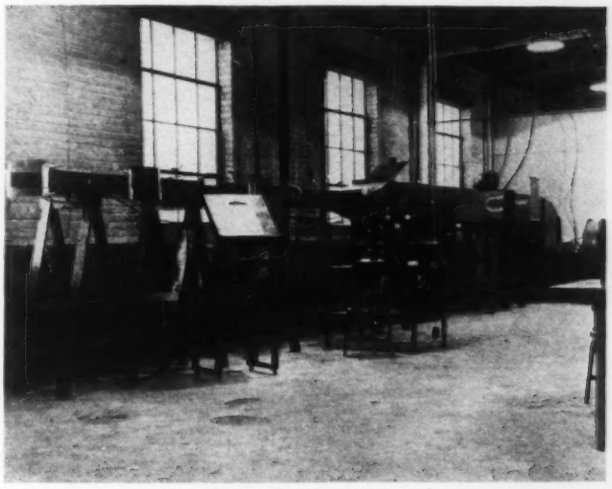


Fig. 7—Horizontal duct arrangement for investigating performance of outlets, University of Wisconsin

Cooling Towers, Evaporative Condensers and Spray Ponds, 17

B. M. Woods, *Chairman;* **W. W. Cockins, S. C. Coey, E. H. Kendall, S. R. Lewis, F. C. McIntosh*, H. B. Nottage, J. F. Park, E. T. Selig, Jr., E. W. Simons, E. H. Taze.**

The work on cooling towers and spray ponds has progressed along the following course since the previous report.

1. Tests on a spray tower, with several different types of nozzles (3) were finished.

2. Further work is being done, especially with the purpose of evaluating nozzle performance.

3. Test results on two types of nozzles in a spray pond have been evaluated.

4. The performance of spray towers and ponds has been presented on a unit volume conductance basis.

5. A method of measuring unit mass conductances of single elements has been proposed in collaboration with others.

To date five papers have been released for publication in the Society JOURNAL and other technical literature covering the work of this committee. The staff at the University of California contributed a section on cooling tower design for inclusion in the 1942 edition of the GUIDE.

Psychrometry, 18

F. R. Bichowsky, *Chairman;* **D. B. Brooks, W. H. Carrier, H. C. Dickinson, A. W. Gauger, J. A. Goff, William Goodman, A. M. Greene, Jr., L. P. Harrison, F. G. Keyes, A. P. Kratz, D. M. Little, Axel Marin*, D. W. Nelson, W. M. Sawdon, F. O. Urban.**

The first progress report sponsored by this committee was presented at the 1941 Semi-Annual Meeting covering cooperative work conducted at the University of Pennsylvania. This paper gave preliminary results on the experimental measurement of the interaction constant for moist air at a temperature of 15 C.

Owing to the desirability of making some improvements in the apparatus before attempting to obtain final results covering as wide a range of temperature as possible, no additional data could be presented at the present time. However, a paper covering recalculations of the vapor pressure of ice, which is a part of the ultimate objective of the committee in formulating more accurate thermodynamic properties of moist air, will be presented at the 1942 Annual Meeting.

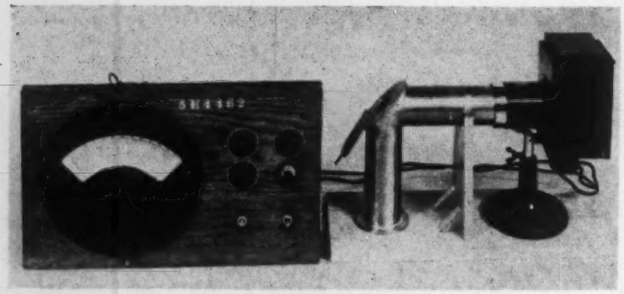


Fig. 8—Apparatus for measuring relative discoloration of air samples by reflected light, University of Minnesota

Corrosion, 19

A. R. Mumford, *Chairman;* H. E. Adams, N. D. Adams, J. F. Barkley, L. F. Collins, W. H. Driscoll, T. J. Finnegan, W. Z. Friend, R. R. Seeber, E. T. Selig, Jr., F. N. Speller, C. M. Sterne, J. H. Walker*.

Plans have been formulated for a long range program of investigation, and financial support has been obtained for the first phase of this program, which will cover an investigation of the solubility of carbon dioxide in otherwise pure condensate at low partial pressures and at condensate temperatures.

The committee has been considering a preliminary report of the cooperative work at the Michigan College of Mining and Technology, where it is planned to continue this investigation without expense to the Society. A paper covering corrosion of several alloys in air washers of air conditioning systems was prepared by a member of the committee for presentation at the 1942 Annual Meeting of the Society.

In line with its long range program, the committee has initiated and is now considering a paper presented from industry on the present non-technical status of counter-corrosion agents, such as are met with in the group of organic amines. It is planned that this paper will be available for consideration by the Society in the near future.

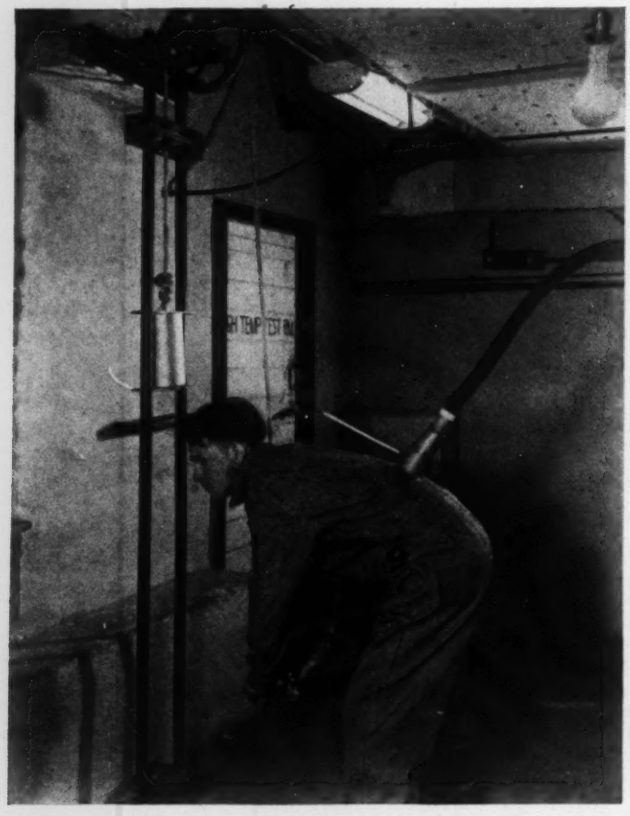


Fig. 9—Study of local cooling of worker in hot industry, ASHVE Research Laboratory

Flow of Fluids Through Pipes and Fittings, 20

S. R. Lewis, *Chairman;* L. A. Cherry, G. C. Davis, T. M. Dugan, Earle W. Gray, R. T. Kern, H. A. Lockhart, Axel Marin*, R. F. Taylor, E. L. Weber.

The major objective of this committee is to determine proper allowances for resistances to flow of fluids of various kinds through pipes, valves, fittings, heat receivers and transmitters.

The activities of the committee have been confined largely to a cooperative research project being investigated at the Agricultural and Mechanical College of Texas. Special earmarked funds were solicited to cover the expense of testing a large section of six inch pipe with valves, fittings and sections of both welded and screwed methods of assembly.

The first phase of this study has been completed and results covering a comparison of the friction heads in screwed and welded elbows are to be presented at the 1942 Annual Meeting.

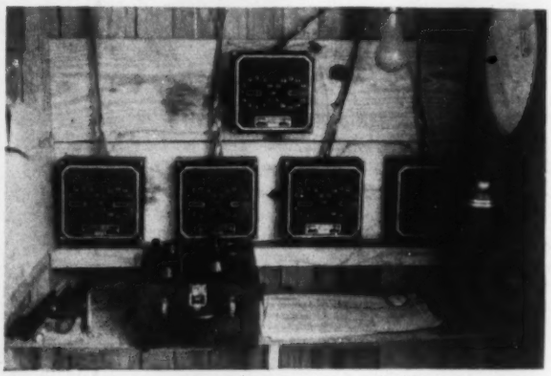


Fig. 10—Instrument booth for attic fan project showing thermocouple switches and potentiometer, Georgia School of Technology

Studies to determine the influence of temperature on the loss of head and the friction loss resulting from corrosion of the inner pipe surface are now under investigation.

Fuels, 21

R. A. Sherman, *Chairman;* R. M. Conner, R. S. Dill, A. C. Fieldner, L. N. Hunter, S. Konzo, W. M. Myler, Jr., H. J. Rose*, C. E. Shaffer, T. H. Smoot, R. K. Thulman, E. C. Webb.

This committee was appointed in the summer of 1941 and has held no meetings but has organized itself for future activities by correspondence. The scope of the committee has been defined as:

The committee is concerned with the production of heat for comfort heating and for service hot water as in residences, apartments and office buildings. This includes the characteristics of fuels, the mechanism of the combustion of fuels, the design of equipment for the combustion of fuels, the design of boilers, furnaces, and space heaters, the design of automatic controls for such equipment, and the equipment by which the waste products, ash and flue gases, are removed from the heating equipment. Its functions are the encouragement of dissemination of existing knowledge in these fields by papers presented before local and national meetings of the Society and publication in the JOURNAL, and the initiation, support, and supervision of research to obtain information now lacking.

Suggestions have been received for a number of papers for technical sessions of the Society and for problems on which research projects are needed. At an early meeting of the committee, it is expected that one or two projects will be selected for sponsorship by the committee and steps taken to initiate the work.

PRESIDENT EASTWOOD RETURNS TO ACTIVE DUTY

Pres. E. O. Eastwood has returned to his duties at the University of Washington, Seattle, after an eight-day siege of pneumonia in Lakeside Hospital, Kansas City, Mo. He was en route East for a Council meeting in Philadelphia and after addressing the Kansas City Chapter, April 6, he found it impossible to continue his trip and fill speaking engagements at St. Louis, Buffalo and Philadelphia.

Council members were kept fully informed of President Eastwood's condition through almost daily bulletins from W. A. Russell. President Eastwood greatly appreciated the many messages and flowers that he received from Council and Chapter members during his illness.

The regular quarterly meeting of the Council was held April 9, at the Engineers Club, Philadelphia, Pa., with M. F. Blankin, First Vice-President in the chair, and the following members present: Messrs. J. F. Collins, Jr., S. H. Downs, W. L. Fleisher, E. N. McDonnell, F. C. McIntosh, L. G. Miller, A. J. Offner and L. P. Saunders. Reports of the Council committees were received and the program for the Semi-Annual Meeting was approved. The publication of weather data for a typical City was authorized and there was a detailed discussion of the status of Society research under war-time conditions.

ASHVE MEMBERS ELECTED TO LIFE MEMBERSHIP

C. H. Chalmers
Minneapolis, Minn.

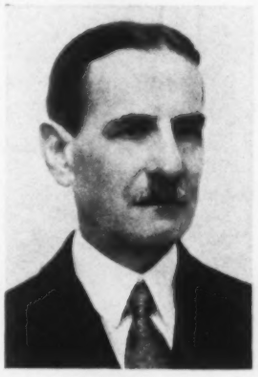
F. E. Giesecke
College Station, Tex.

M. H. Gornston
Jamaica, N. Y.

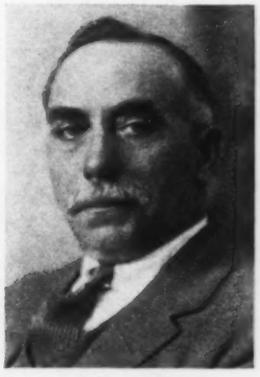
F. D. B. Ingalls
Reading, Mass.

W. J. Olvany
New York, N. Y.

O. J. Prentice
Chicago, Ill.



C. H. Speckman
Philadelphia, Pa.



Andrew Sheret
Victoria, B. C.

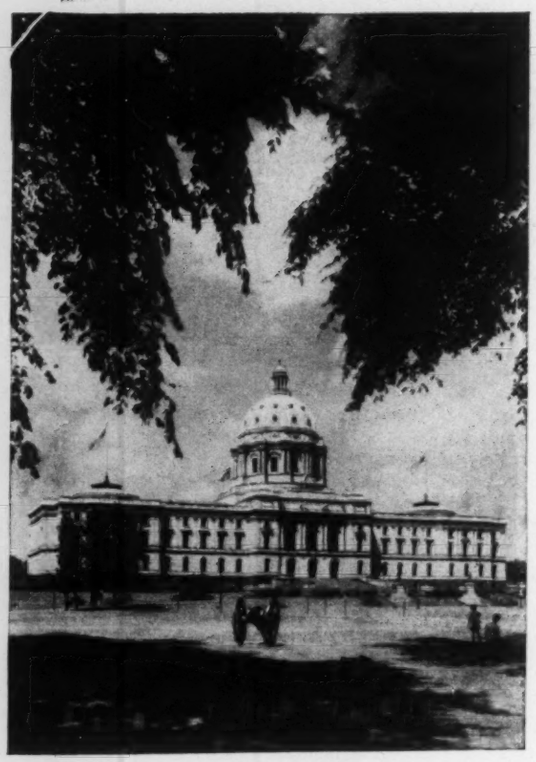
R. C. Taggart
Albany, N. Y.

A. O. Blackman
Atlanta, Ga.

E. W. Gibbs
Providence, R. I.

G. J. Wallace
East Elmhurst, N. Y.

J. J. Raine
Burlington, Vt.



State Capitol

Come to the Semi-Annual Meeting

St. Paul, Minn. - June 15-17

Rushmore Memorial in Black Hills

FUEL CONSERVATION and the elimination of wasteful methods in heating and cooling practice to meet the war emergency will be featured in the discussions at the Semi-Annual Meeting of the Society which will be held in St. Paul, Minn., June 15-17, with headquarters at the Hotel St. Paul. All arrangements are in the hands of the members of the Minnesota Chapter, headed by R. E. Backstrom, St. Paul.

Early arrivals at the meeting are invited to participate in an informal gathering on Sunday evening and enjoy the famous St. Paul smorgasbord dinner. Monday morning will be devoted to registration, Council and Committee meetings, and a Get-Together Luncheon will be held at noon.

There will be three technical sessions, the first at 1:30 p. m., June 15, the second at 9:30 a. m., June 16, and the third at 9:30 a. m., June 17. Three technical papers are scheduled for presentation at each session. Among the subjects to be discussed are, effectiveness of insulation, the specific heat of thermal insulating materials, performance characteristics of vapor heating systems, warm air heating system performance, the testing of air cleaning devices, physiological studies in war industries and air conditioning of blackout plants.

Prof. F. B. Rowley, R. E. Backstrom, and E. F. Bell

The annual golf tournament will be held on June 16, for the Research Cup and the Eichberg Memorial Cup. E. F. Bell, chairman of the Golf Committee has made an early start in the collection of golf balls, and promises an adequate supply. The corps of inspectors is shown at work in the accompanying picture.

Tuesday evening the Semi-Annual banquet will be held at which the past-president's Memory Book will be presented to W. L. Fleisher, New York. Arrangements for this function are in the hands of H. M. Betts.

A special ladies program is being developed by Mrs. R. E. Backstrom, and the visiting ladies will enjoy some novel entertainment features.

Minnesota, with its 10,000 lakes and innumerable rivers and streams, offers every type of natural scenic beauty, and in the summer is a fisherman's paradise. There is every type of water sport available, bathing, swimming and boating, so that those who feel the strain of War will find facilities for a vacation that will refresh and invigorate them.

Members of the Minnesota Chapter want every member of the ASHVE and his friends to enjoy their stay in the State Capital, St. Paul, June 15-17.

Following the meeting those who want a few days rest will also find that the Black Hills offer many attractions and a visit to Mt. Rushmore National Monument, a trip through the Bad Lands to historic Deadwood and the Homestake area, will be made en route.

SCHEDULE OF EVENTS
SEMI-ANNUAL MEETING

St. Paul, Minn.—St. Paul Hotel
June 15-17, 1942

June 14

3:00 p. m. Registration and Reception of early arrivals (*Capitol Room*)
6:30 p. m. Smorgasbord Dinner (*Club Casino*)
Minnesota Movies

June 15

9:00 a. m. Registration (*Capitol Room*)
Minnesota Chapter Ladies Headquarters (*Sibley Room*)
9:30 a. m. Council Meeting (*Room 234*)
10:00 a. m. Nominating Committee Meeting (*Room 334*)
12:15 p. m. Get-Together Luncheon (*Club Casino*)
1:30 p. m. TECHNICAL SESSION (*Continental Room*)
Three papers
4:30 p. m. Committee on Research (*Room 234*)
7:30 p. m. Informal Get-Together (*Club Casino*)

June 16

9:30 a. m. TECHNICAL SESSION (*Continental Room*)
Three papers
12:15 p. m. Men's Luncheon at Golf Club
1:30 p. m. Golf Tournament (Research Cup and Eichberg Memorial Cup)
7:30 p. m. Dinner and Dance (*Continental Room*)

June 17

9:30 a. m. TECHNICAL SESSION (*Continental Room*)
Three papers
1:30 p. m. Golf Matches and Sightseeing and Inspection Trips
8:45 p. m. Leave for Black Hills and National Park Trips

R. E. Backstrom

A. B. Algren

N. D. Adams

H. E. Gerrish

F. B. Rowley

H. M. Betts

Committee on Arrangements

R. E. Backstrom, *General Chairman*
A. B. Algren, *Vice-Chairman*

Executive:

N. D. Adams — H. E. Gerrish — F. B. Rowley

Banquet: H. M. Betts, *Chairman*
Entertainment: E. F. Jones, *Chairman*
Finance: M. S. Wunderlich, *Chairman*
Golf: E. F. Bell, *Chairman*
Ladies: Mrs. R. E. Backstrom
Publicity: D. B. Anderson, *Chairman*
Reception: M. H. Bjerken, *Chairman*
Transportation: J. F. Stafford, *Chairman*

Board of Governors:

William McNamara — G. A. Dahlstrom

E. F. Jones

M. S. Wunderlich

E. F. Bell

G. A. Dahlstrom

M. H. Bjerken

J. F. Stafford

William McNamara

D. B. Anderson

BLANKIN ADDRESSES MONTREAL

March 25, 1942. The regular monthly meeting was held with Pres. F. A. Hamlet presiding. The minutes of the previous meeting were read and approved.

President Hamlet introduced M. F. Blankin, Philadelphia, Pa., First Vice-President of the Society, who made a few remarks on the work of the Society. Mr. Blankin then presented a talk on hot water heating, which was one of the most interesting presented at the local meetings, as reported by A. M. Peart, secretary of the Chapter. Of particular interest was the description and data on the housing schemes and particularly their heating systems.

During the discussion of these heating systems, it was moved by S. S. Colle, seconded by A. E. Watts, that a committee be formed to study a uniform method of determining heat loss for heating design. It was pointed out that this should be done with a view to obtaining the greatest economy in the use of metal without sacrificing heating efficiency, as a contribution to the National Emergency.

The motion is to be discussed further by the executives with a view to taking further action with the Toronto Chapter, the National Research Council and the Society.

February 16, 1942. The regular meeting of the Montreal Chapter of the Society was presided over by Pres. F. A. Hamlet. The minutes were read and approved, and G. Lorne Wiggs moved a vote of thanks to Treas. R. R. Noyes, for the completeness of the report he presented. R. F. Wormley made a motion that a Victory Bond be purchased with surplus funds. The motion was seconded by S. S. Colle and a bond will be bought if it is found to be possible.

Due to the fact that H. G. S. Murray had been unexpectedly detained in Halifax, it was impossible for him to arrive in time to give his talk on warm air heating systems, as he had planned. However, the Chapter was fortunate on such short notice in securing a film on *Heat and Its Control.* This covered various industrial insulating applications and also the manufacture of industrial insulating material. The meeting was enjoyed and after a vote of thanks was extended to those responsible for the film, the meeting adjourned.

DOWNS AND RUSSELL NORTH TEXAS GUESTS

March 7, 1942. The meeting of the North Texas Chapter was held at the Stoneleigh Hotel, Dallas, with 14 members present for luncheon.

S. H. Downs, Kalamazoo, Mich., Second Vice-President of the ASHVE, and W. A. Russell, Kansas City, Mo., member of the Council of the Society, were among the guests.

Pres. T. H. Anspacher appointed the committees for the year, urging the cooperation of all in order to maintain the local Chapter during the emergency. Mr. Russell, who is chairman of the Society's Membership Committee, gave some helpful suggestions in this connection, stating that the Society lost approximately 300 members during the past year, but gained approximately 300 new members.

Mr. Downs discussed the affairs of the Society, showing slides which gave the distribution of the membership by states. He urged that the North Texas Chapter cooperate in securing new members and holding the present ones, discussing finances, dues and research in this connection. He then spoke on *The Flow of Air and Gases in Various Systems,* taking temperature and density into consideration, illustrating the various formulae used, comparing their accuracy and application to various systems. After a period of discussion a rising vote of thanks was extended to Mr. Downs, and the meeting adjourned at 4:30 p. m.

WASHINGTON, D. C., TRIES INFORMATION PROGRAM

March 11, 1942. The sixth regular meeting of the Washington, D. C. Chapter of the Society was held at the Dodge Hotel, with 31 members and guests in attendance. Following dinner, Pres. F. A. Leser opened the business meeting and the minutes of the previous meeting were approved as read.

President Leser announced the appointment of the following to serve on the nominating committee: Lt. Commdr. T. H. Uhdahl, *chairman;* F. C. Hackett and J. H. Clarke.

F. M. Thuney read a letter from F. C. McIntosh, chairman of the Committee on Research, commending Prof. H. H. Koster, George Washington University and Chapter member, on the work he has done on collecting weather data in 1941.

Members and guests then retired to the Garden House where a quiz type of program was held. Prof. *"Clifton Wataman"* Koster propounded questions submitted by members to a board of alleged experts comprising Messrs. T. H. Urdahl, R. S. Dill, F. M. Thuney and F. F. Espenschied. Guest experts were H. H. Downes and A. S. Gates, Jr. Much entertainment was afforded by the answers to questions involving heating and air conditioning problems, and more amazement was expressed over some of the questions themselves. A rising vote of thanks was extended to the *experts* for their services in lieu of material appreciation.

ONTARIO NOMINATES OFFICERS

April 6, 1942. The regular monthly meeting of the Ontario Chapter was held at the Royal York hotel, with 53 members and guests in attendance, and Pres. C. Tasker presiding.

President Tasker announced the winners of the Ontario Chapter's contest between the junior and senior students at the University of Toronto for the best thesis on heating, ventilating or air conditioning. D. J. Parrish was selected as the writer of the best, and his subject was on measurement of steam flow. The next was on ventilation of a heat treating plant, and was compiled by E. F. Hendricks. The third one selected was on air compressors and was prepared by H. H. Madgett.

President Tasker then announced that in the future all new members from Canada will send a check for $10.00 with their applications instead of the $28.00 as has been done in the past. The New York headquarters office will then bill the new members $18.00 for their annual dues. The reason for this change in procedure is to meet the new exchange regulations between the United States and Canada.

H. D. Henion, chairman of the nominating committee, reported the following candidates for the various offices for the 1942-43 season to be

voted on at the annual meeting in May: *President*—D. O. Price; *Vice-President*—W. C. Kelly; *Secretary-Treasurer*—H. R. Roth; *Board of Governors*—E. R. Gauley, A. S. Morgan, H. G. Hill and C. Tasker, *ex-officio*.

The auditors for the coming year were then announced as H. S. Moore and H. G. Hill, and then President Tasker called upon the principal speaker, Mr. Vanderburg, Toronto, who spoke on *Copper Goes to War*, and which he illustrated with a colored movie. Mr. Vanderburg explained the difficulties in obtaining copper and brass for the civilian requirements and also explained the difficulties confronting the industry in supplying sufficient quantities of this material for the war effort. An interesting discussion followed Mr. Vanderburg's address before adjournment.

S. H. DOWNS VISITS KANSAS CITY

March 9, 1942. In the absence of Pres. Gustav Nottberg, M. M. Rivard, vice-president, called the Kansas City meeting to order at the President Hotel, Kansas City, Mo., with a buffet supper preceding the meeting. The minutes were read and approved, and following the report by the membership chairman, Vice-President Rivard reported on the 48th Annual Meeting of the Society in Philadelphia.

In an open discussion it was suggested that a new chapter membership roster be prepared to include all members in the Kansas City area who are members of the Society but not members of the Kansas City Chapter.

S. H. Downs, Kalamazoo, Mich., second vice-president of the ASHVE, was then introduced as the guest of the evening. Mr. Downs, before entering into his technical discussion, explained some of the progress of the Society in relation to research and increased Chapter activities. He also stated that the membership in the Society was, at the present time, at its highest point, but in relation to its potential membership, the Society had a very limited number.

Mr. Downs discussed the flow of air and gases in various systems and discussed the effect of densities, temperatures, and composition of gases on the static pressure characteristic of systems. Mr. Downs' complete knowledge of the subject commanded the full attention of the members, and after an informal discussion which followed Mr. Downs' presentation, the meeting adjourned.

KRATZ GUEST AT NEW ORLEANS LUNCHEON

March 5, 1942. The Delta Chapter held a luncheon meeting at Arnaud's Restaurant, New Orleans, to hear Prof. A. P. Kratz, University of Illinois, Urbana, Ill., lecture on the research results in rating gravity and forced hot water plants. The luncheon was attended by 33 members and guests, and the meeting was called to order by Pres. G. C. Kerr.

Professor Kratz' talk was enjoyed and appreciated by the members, particularly that portion of the lecture dealing with the air conditioning of residences.

It was announced by the Delta Chapter that a motion was made at a previous meeting that the evening meetings be discontinued for the duration, and that all activities be confined to luncheon meetings. It was found that due to the intensive activities of most of the Delta members in the war effort that the night attendances were poor.

A committee comprised of G. E. May, *Chairman;* J. J. Friedler, Jr., G. A. Hero, Jr., F. D. Graham, John Devlin, Fritz Gutknecht and L. V. Cressy, were appointed to call on the head of the local Civilian Defense Co-ordinator with a view of working with him in the handling of ventilating problems during blackouts.

SOUTHERN CALIFORNIA HEARS B. M. WOODS

March 4, 1942. The regular meeting of the Southern California Chapter was held at Eaton's Chicken House, Los Angeles, with 50 members and guests present, which was believed to be an exceptional turnout, coming as it did one week after the supposed air raid.

After dinner Pres. A. J. Hess called the meeting to order and introduced C. L. Peterson of the Golden Gate Chapter and S. L. Rolland, past president of the Oklahoma Chapter. President Hess then announced the appointment of J. Frank Park as chairman and C. G. Hokanson and Art Theobold as members of the Nominating Committee, to recommend officers for the coming year.

The meeting was then turned over to H. H. Bullock, who introduced George Hjelte, director of Defense Council, City of Los Angeles, who spoke on the citizen's duty in local defense and the manner in which the defense council was organizing the various divisions in order to have a smooth working organization in case of an emergency.

Dr. B. M. Woods, professor of engineering at the University of California and a member of the Society's Council, and past president of the Golden Gate Chapter, was then introduced as the principal speaker. Dr. Woods gave an interesting talk on the problems of the engineer in war time, which he covered thoroughly, and which was enjoyed by those in attendance.

DR. WINSLOW SPEAKS AT M.I.T.

March 17, 1942. The Massachusetts Chapter held its March meeting at the Walker Memorial, Massachusetts Institute of Technology, and was called to order by Pres. J. W. Brinton.

The secretary read the names of the Board of Governors' nominations and then announced the various jobs available for heating and ventilating engineers. D. J. Edwards introduced Dr. C.-E. A. Winslow, professor of Public Health at Yale University and director of the John B. Pierce Laboratory of Hygiene, New Haven, who gave a very interesting talk on *The Human Element in Air Conditioning*. There was considerable discussion on the effects of humidification, and two new terms were introduced, the *Met* as a measuring stick of metabolism and the *Clo* as an index of body shielding by clothing.

Dr. Winslow was given a well deserved rising vote of thanks, and the meeting adjourned at 9:00 p. m.

February 16, 1942. The February meeting of the Massachusetts Chapter was a joint Fuels Conservation Session with the *National District Heating Association* and the *Engineering Societies of New England*. It was held at the Massachusetts Institute of Technology with President Jackson (*ESNE*) presiding and 225 were present.

R. L. Bowditch, chairman of the solid fuels committee of New Eng-

land Council, was introduced and he gave a clear picture of the present coal situation in New England and showed the need for every coal user to cooperate to meet an emergency.

J. C. Richdale told of the problems of oil distribution and the lack of reserves in New England. C. M. F. Peterson, assistant superintendent of buildings and power at MIT, and Joseph Sheehan, a plant engineer, in turn, gave many helpful suggestions as to what can be done to check the heating systems, both domestic and industrial, to conserve fuel.

As reported by the secretary of the Massachusetts Chapter, the meeting was most interesting and successful. The meeting adjourned at 10:00 p.m.

JOINT MEETING OF ONTARIO AND WESTERN NEW YORK

March 9, 1942. A joint meeting was held between the Ontario and Western New York Chapters at the Hotel General Brock, Niagara Falls, Ont., with 81 Canadian members and 41 Western New York members present.

The program was arranged by the Ontario Chapter under the direction of H. R. Roth and V. J. Jenkinson, assisted by H. C. Schafer representing the Western New York group.

The meeting was called to order with H. D. Henion acting as chairman of the meeting, and with Pres. W. R. Heath of Western New York and Pres. C. Tasker of the Ontario Chapter as the principal speakers.

Following dinner the members and guests enjoyed short talks by several of the officers and toastmaster, followed by a moving picture consisting of a presentation of the Bell Aircraft Co., and other films of present-day interest. President Tasker then extended a welcome to their neighbors across the border, and President Heath responded with the best wishes from the Western New York Chapter.

The program committee designed this meeting to get away from the usual technical session, and according to the reports from each of the Chapters, the meeting was one of the finest ever held by either Chapter, resulting in a splendid occasion for all concerned.

The meeting was adjourned with an unanimous feeling that the joint meeting between the two Chapters should be continued each year in the future. The Western New York group returned to Buffalo with a feeling of real gratitude to their Canadian brethren and the sincere knowledge of a very good time having been had.

WESTERN NEW YORK HEARS ACCOUNT OF AUSTRIAN INVASION

February 9, 1942. The February meeting of the Western New York Chapter was held at the University Club, Buffalo, and was well attended. H. C. Schafer reported that plans were progressing nicely for the joint Western New York and Ontario meeting scheduled for March. C. A. Gifford, W. R. Heath, G. E. Adcina and B. C. Candee were appointed to serve on the joint meeting committee.

Roswell Farnham and W. E. Voisinet reported on the Air Raid Shelter Committee, of which they are members. They were appointed by Mayor Thomas C. Holling with the purpose of studying and setting up standards for air raid shelters. Both these members have been studying the problem particularly from a heating and ventilating standpoint, and while some progress has been made, the final conclusions were not ready to be reported.

President Heath, as chapter delegate to the Annual Meeting in Philadelphia, reported on the meeting, stating that there had been a lengthy debate on the by-laws in regard to the nominating committee, but after due consideration, it was tabled for further study by the Committee on Constitution and By-Laws.

At this point President Heath introduced the speaker, Colonel Burton Witherspoon, vice-president of the Buffalo Chamber of Commerce, who gave a most interesting talk entitled, *The Will to Win.* Colonel Witherspoon talked from an unusually colorful background inasmuch as he had been in Europe, and particularly Germany and Austria, at the time the Germans took over Austria, and his eye-witnessed accounts of what took place at that time were very vividly and interestingly told. From his experiences Colonel Witherspoon has drawn certain very definite conclusions which were of decided interest to the entire membership. His talk was very well received and a rising vote of thanks was accorded him, followed by adjournment.

CORROSION DISCUSSED AT PITTSBURGH

March 9, 1942. Pres. E. C. Smyers called the March meeting of the Pittsburgh Chapter to order at the Hotel Roosevelt, with 31 members and guests present, and the minutes of the previous meeting were approved as read.

Following the reports of the various committee chairmen, President Smyers appointed the following to serve on the nominating committee: R. B. Stanger, *chairman:* F. C. McIntosh and J. F. Collins, Jr.

President Smyers then introduced Owen Rice, chemist of the Hall Laboratories, who spoke on corrosion in heating and air conditioning systems. Mr. Rice discussed the various constituents of natural waters which cause corrosion and then told how their solubility is affected by temperature and pressure. He then told of the methods now used for controlling corrosion in plumbing lines, heating systems, evaporative condensers and cooling towers. The audience expressed its appreciation by the extensive discussion that followed, before the meeting adjourned at 9:30 p.m.

ST. LOUIS MEMBERS MEET

March 3, 1942. Vice-Pres. M. F. Carlock called the meeting to order at the Candlelight House, St. Louis County, with 24 members and guests present. Following the reading of the minutes of the previous meeting, which were accepted as read, C. F. Boester, recently appointed to serve a three-year term on the Committee on Research of the Society, reported on the 48th Annual Meeting in Philadelphia. Mr. Boester outlined some of the financial problems confronting him as chairman of the Finance Committee of the Committee on Research.

The secretary then announced several committee appointments, fol-

lowed by a discussion by Vice-President Carlock on heat losses as presented in a paper given at the Society's San Francisco meeting by P. D. Close.

W. D. Sampson, consulting engineer of St. Louis, was introduced. His subject was *Mechanized Civilian Defense,* and his coverage was based upon his activities with the Office of Civilian Defense, also upon a digest of all available recent publications bearing upon the subject. He traced the history of air raids upon civilian populations, from the 1916 raids upon London, through the activities of the Spanish Civil War, to the blitz assaults upon London in 1940. He concluded that the main reason for such assaults upon non-military objectives was to divert valuable efforts and materials for defense of the civilian populations, and of course to harass and interrupt normal functioning of production activity.

Mr. Sampson brought out that the blackout program is aimed as much at deceiving enemy raiders as at entirely concealing our cities, since moonlight nights, reflections from lakes, streams, etc., can partly nullify blackout efforts. False street lighting patterns, he explained, can mislead raiders, and camouflage enters in, to alter apparent outlines of important buildings and landmarks. He further described methods of reinforcing present structures against fragmentation, mainly by sandbags. His discussion covered various types of gases likely to be used, although he pointed out that an effective gas attack against a large metropolitan center would involve a staggering amount of preparation, with thousands of plane loads. Handling of incendiary bombs was also described. He brought out that they could be very troublesome if not guarded against skillfully.

At the conclusion of Mr. Sampson's talk a spirited discussion took place, with the speaker answering many questions. He assured the meeting that the Office of Civilian Defense has a definite program which will offer the maximum practical defense, as consistent with our active military production efforts.

After a rising vote of thanks to Mr. Sampson for his very interesting and thorough presentation, the meeting adjourned at 10:15 p.m.

February 3, 1942. There were 18 members and guests at the monthly meeting held at the Candlelight House with Vice-President Carlock presiding. The January minutes were read and approved, followed by reports from the treasurer and several committee chairmen.

R. T. Toensfeldt gave a brief report on the 48th Annual Meeting in Philadelphia, which he and Pres. D. J. Fagin also attended. He mentioned that the proposed amendment on the Nominating Committee selection had met with considerable opposition at the Meeting and had been tabled for further study by the Society's Committee on Constitution and By-Laws.

B. C. Simons then introduced C. M. Sanders, Jr., who presented a working demonstration of an electrical dust precipitator, which he illustrated with slides descriptive of types of dusts, size comparisons, etc. He also described the precipitator in its relation to the removal of a smoke caused by burning machine oil on a hot plate, the smoke particles being about 0.3 microns in size. After his talk, Mr. Sanders answered numerous questions, and the meeting adjourned at 9:00 p.m. with a rising vote of thanks for Mr. Sanders' very able presentation.

MINNESOTA PREPARING FOR SEMI-ANNUAL MEETING

March 2, 1942. The March meeting was held at the Athletic Club, St. Paul, with 55 members and guests present. The meeting was called to order by Pres. H. M. Betts, and the February minutes were approved as read by Secy. D. B. Anderson.

R. E. Backstrom, General Chairman for the Semi-Annual Meeting to be held in St. Paul, June 15-17, 1942, announced the following in charge of arrangements: Prof. A. B. Algren, vice-chairman; Prof. F. B. Rowley, H. E. Gerrish and N. D. Adams comprise the Executive Committee. The committee chairmen are as follows: E. F. Bell—*Golf;* H. M. Betts—*Banquet;* M. H. Bjerken—*Reception;* J. F. Stafford—*Transportation;* D. B. Anderson—*Publicity;* E. F. Jones—*Entertainment;* M. S. Wunderlich —*Finance;* Mrs. R. E. Backstrom —*Ladies.*

Mr. Backstrom stressed the fact that every member of the Chapter is a member of a committee. The tentative program was discussed and the responsibility of each committee was outlined. Members who contributed to the discussion were Messrs. Adams and Gerrish and Professors Algren and Rowley.

The second portion of the program was devoted to the showing of a new sound picture entitled *Timber to Temperature Control,* depicting the development of a fibre insulation from timber in the farmer's wood lot, through the manufacturing stage to its application as insulation in the domestic refrigerator. A new pneumatic process by which bulk fibre insulation is applied was described. The meeting adjourned at 9:15 p.m.

RADIANT HEATING TOPIC AT IOWA

February 10, 1942. The February meeting was held in the Kirkwood Hotel, Des Moines, Ia., with 21 members and guests present, and Pres. Perry La Rue presiding. The minutes of the previous meeting were read and approved, and President La Rue reported that S. H. Downs, second vice-president of the ASHVE, had been selected as the speaker for the March meeting.

President La Rue then announced that the Semi-Annual Meeting of the Society will be held in St. Paul, Minn. June 15-17, and suggested that as many members as possible from the Iowa Chapter plan to attend.

Prof. R. K. Smith and Prof. A. C. Durland presented the program in the absence of Prof. R. A. Norman. Professor Smith described instruments used and methods of test used in experiments on radiant heating. He also gave considerable information on the problems confronting the engineer in the design of panel or radiant heating, particularly on the establishment of the mean radiant temperature selection and location of coils, coil area and surface temperature. Professor Durland described the heating system in his own home, which is a combination of air warmed panels and forced warm-air heating. The results he reported were interesting and contrary to many popular beliefs.

Candidates for Membership

The Constitution of the Society, as now amended, requires the following mode of procedure in voting on applicants for membership in the Society. All applications for membership are to be sent to the Secretary and the names of applicants and their references shall be printed in the next issue of the JOURNAL of the Society or sent to the members in other approved manner as ordered by the Council. When replies are received from references, the Candidate's application shall be submitted to and acted upon by the Committee on Admission and Advancement as soon as possible.

When the Committee on Admission and Advancement has acted favorably upon a Candidate's application and assigned his grade, the Council shall vote upon the election of the proposed Candidate for membership by letter ballot. During the past month 28 applications for membership have been received and the names of these men and their sponsors are published in the following list.

Members are requested to scrutinize the list with care. The Committee on Admission and Advancement, and in turn, the Council, urge the members to assume their share of responsibility of receiving these candidates into membership by advising the Secretary promptly of any whose eligibility for membership is in any way questioned.

All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote.

Unless objection is made by some member by May 15, 1942, these candidates will be balloted upon by the Council. Those elected to membership will be notified by the Secretary immediately after election.

CANDIDATES	REFERENCES	
	Proposers	*Seconders*
ACHENBACH, PAUL R., Asst. Mech. Engr., National Bureau of Standards, Washington, D. C.	R. S. Dill R. K. Thulman	F. F. Espenshied E. H. Lloyd
BARTELS, CHARLES J., Owner, Automatic Stoker & Engineering Co., Parkersburg, W. Va.	L. G. Huggins A. H. Goelz	W. C. Goodwin (*AIEE*) W. R. Cooper (*Non-Member*)
BAXTER, JULIAN F., Pres., Automatic Coal Burning Corp., Atlanta, Ga.	F. L. Laseter L. F. Lawrence, Jr.	A. H. Koch W. M. Garrard
BEVINGTON, WARREN C., Pres., Bevington-Williams, Inc., Engrs., Indianapolis, Ind.	S. E. Fenstermaker R. E. Poehner	C. H. Hagedon J. H. Niesse
DAVIS, MAURICE M., Chief Draftsman, Anemostat Corp. of America, Elmwood, Conn.	F. J. Kurth L. W. Fischer	F. Honerkamp E. Goldsmith
DEMENA L., ISABEL, Student, National School, Los Angeles, Calif.	M. I. Blumenthal A. J. Hess	W. O. Stewart H. H. Bullock
DEVRIES, JOHN J., Insulation, Grand Rapids, Mich.	T. D. Stafford W. W. Bradfield	F. C. Warren S. W. Todd, Jr.
EDWARDS, CARVIS E., Design Engr., Consoer, Townsend & Quinlan & Battey & Childs, Parsons, Kans.	M. J. Stevenson H. C. Smith	J. S. Hopper J. A. Bishop
GORDON, WILLIAM D., Vice Pres.-Gen. Mgr., Canada Register & Grille Co., Ltd., Toronto, Ont., Canada (*Reinstatement*)	V. J. Jenkinson M. S. Woollard	C. Tasker R. W. Bayles
GOULD, JAMES L., Erection Supt., Cooke-Bain Air Conditioning & Sheet Metal Contractors, Tulsa, Okla.	T. H. Anspacher William Ball	C. J. Doughty P. C. Leffel
HOLE, WILLIAM G., Mgr. (Airfilter Div.), Darling Bros., Ltd., Montreal, Que., Canada.	R. R. Noyes C. W. Johnson	Aylmer Hamlet Leo Garneau
LANDFRIED, CHARLES L., Ventilation Engr., Gielow, Inc., New York, N. Y.	W. E. Heibel J. W. Markert	J. A. Heller Arthur Ritter
LEHMAN, JOHN L., Sales Engr., Columbia Radiator Co., East Orange, N. J.	A. H. Schroth R. P. Strevell	B. V. Blazer A. V. Hutchinson
MURPHY, CHARLES G., Ventilation Engr., Wright Aero, Lockland, O. (*Reinstatement*).	I. B. Helburn R. J. Blum, Jr.	R. W. Sigmund G. B. Houliston
PADDEN, BERNARD, Research Engr., Anemostat Corp. of America, New York, N. Y.	F. J. Kurth F. Honerkamp	H. K. Kunen Elliot Goldsmith
PEARCE, EDWARD A., Engr. & Chief Draftsman, E. Wingfield-Bowles & Partners, Northwood, Middlesex, England.	G. N. Haden W. L. Swain	J. J. Fraser V. J. Kennett
PINNEY, THEODORE M., General Projects Engr., The Austin Co., Cleveland, O.	D. L. Taze Paul Gayman	J. A. Schurman F. A. Kitchen
RAY, JOHN A., Sales Engr., W. E. Lewis & Co., Dallas, Tex.	Ross Zumwalt G. A. Linskie	R. G. Lyford L. C. McClanahan
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Candidates Elected

In the past issues of the JOURNAL of the Society the names of the following men were listed as Candidates for Membership. The membership grade of each Candidate has been assigned by the Committee on Admission and Advancement and balloted upon by the Council. We are now instructed by the Council to post herewith, as required by Art. B-III, Sec. 8, of the By-Laws, the following list of candidates elected:

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LAWRENCE, LEWIS F. JR., Br. Mgr., Minneapolis-Honeywell Regulator Co., Atlanta, Ga. (*Advancement*)

REX, HARLAND E., Supervisory Engr., Carrier Corp., Chicago, Ill. (*Reinstatement*)

RHEAULT, WALTER E., Research Engr., Young Radiator Co., Racine, Wis.

STEGGALL, HOWARD B., Branch Mgr., United States Radiator Corp., Pittsburgh, Pa. (*Advancement*)

TAYLOR, ARTHUR R., Sales Engr., Darling Bros. Ltd., Toronto, Ont., Canada

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